Comprehensive Assessment and Monitoring Program (CAMP)

Annual Report 1995 - 1997

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AUGUST 1998

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1. Introduction

This first annual report of the Comprehensive Assessment and Monitoring Program (CAMP) has been prepared for the Central Valley Fish and Wildlife Restoration Program Office, U.S. Fish and Wildlife Service (USFWS). The report summarizes estimates of anadromous fish abundance, associated environmental data, and fish and wildlife restoration actions implemented in the Central Valley from 1995 through 1997, pursuant to the enactment of the Central Valley Project Improvement Act (CVPIA).

Background

The CVPIA (Public Law 102-575, Title 34) of October 1992 amends the authority of the Bureau of Reclamation (Reclamation) Central Valley Project (CVP) to include fish and wildlife protection, restoration, and mitigation as an equal priority with other CVP functions, which include navigation, flood control, irrigation, and municipal water supply. Section 3406 (b) of the CVPIA directs the USFWS to develop and implement programs and actions to ensure that by 2002 the natural production of anadromous fish in Central Valley streams will be sustainable, on a long-term basis, at levels at least twice the average levels of natural production during the 1967 - 1991 baseline period.

The Anadromous Fish Restoration Program (AFRP) was established by Section 3406 (b)(1) of the CVPIA. The AFRP established baseline production numbers for Central Valley streams for naturally produced chinook salmon (all races), steelhead trout, striped bass, American shad, white sturgeon, and green sturgeon. Baseline production estimates were developed using monitoring data collected from 1967 through 1991. Production targets for anadromous fish were determined by doubling the baseline production estimates.

The CAMP, which was established by Section 3406(b)(16) of the CVPIA, has two distinct goals:

- To assess the overall effectiveness of actions implemented pursuant to CVPIA Section 3406(b) in meeting the AFRP production targets
- To assess the relative effectiveness of four categories of Section 3406(b) actions (e.g., water management modifications, structural modifications [excluding fish screens], habitat restoration, and fish screens) in meeting AFRP production targets.

This section of the 1997 CAMP Annual Report includes the results of monitoring performed to estimate the natural production of anadromous fish on each watershed for which an AFRP target has been established.

The recommended methods by which data are collected to evaluate progress toward these goals are outlined in the CAMP Conceptual Plan (USFWS 1996). The CAMP Implementation Plan (USFWS 1997a) refined recommendations for adult and juvenile production monitoring programs necessary to achieve CAMP's two primary goals and detailed data management protocols, data analysis methods, and an estimated 5-year budget necessary to implement CAMP.

Progress toward meeting anadromous fish production targets (Goal 1) is assessed based on estimates of adult production of all races of chinook salmon, steelhead trout, striped bass, American shad, white sturgeon, and green sturgeon. Data collected by adult fish monitoring programs are used to calculate annual production estimates for each species and race. Trends in natural production for each species and race are developed by comparing the annual production estimates to the 1967 through 1991 baseline period estimates for each targeted watershed, as identified in the CAMP Implementation Plan. The adult monitoring program relies extensively on existing monitoring programs and is planned to be consistent and long-term (25 to 50 years duration).

Estimates of juvenile chinook salmon production, which are determined by monitoring selected watersheds, are used to evaluate the relative effectiveness of the four categories of restoration actions in increasing production (Goal 2). Evaluating the effectiveness of each category of actions in restoring anadromous fish populations is important for several reasons. Discussions regarding the value of increasing instream flows compared with the value of, for example, screening diversions as the most effective way to restore anadromous fish populations will remain unresolved until sufficient information is available to address the differences among these categories. Allocation of resources to implement actions in different categories could be directed based on which category appears most effective in restoring anadromous fish populations.

Unlike the monitoring effort to assess progress toward achieving doubling goals, which relies on monitoring the natural production of adults, distinguishing the relative effectiveness of categories of actions is accomplished by evaluating juvenile production. Juvenile production is the most direct measure of the effectiveness of categories of actions because, unlike adult fish that have spent most of their lives in the ocean, juveniles have been exposed only to the conditions present in their natal stream. Monitoring juvenile production in selected streams, the actions in each category implemented in each stream, and associated environmental variables provides the best opportunity to measure the effect of a category of action on juvenile production. By monitoring individual streams, categories of actions can be isolated; mainstem rivers impede isolation because they bear the additive or multiplicative effects of numerous CVPIA and non-CVPIA environmental variables. Coupling adult and juvenile production estimates for these selected streams allows the relative effectiveness of categories of actions to be related to progress toward meeting the doubling goals for anadromous fish populations.

Rotary screw trap sampling is used to estimate juvenile production in selected Central Valley streams. A workshop involving agency biologists was held in June 1997 to develop standardized methods for rotary screw trap sampling.

CAMP Methods

CAMP Implementation Goals

The CAMP Implementation Plan describes the components of the recommended adult and juvenile monitoring programs. The recommended adult fish monitoring program for the CAMP species (including all races of chinook salmon) is summarized in Table 1. The recommended juvenile salmon monitoring program is shown in Table 2.

TABLE 1
CAMP: Recommended Adult Fish Monitoring Programs

Watershed	Species/Race	Adult Fish Monitoring Programs*
Chinook Salmon		
American River	Fall-run Chinook Salmon	**Spawning escapement**, hatchery marking, **hatchery returns, in-river harvest**
Battle Creek	Fall-run Chinook Salmon	**Spawning escapement**, hatchery marking, **hatchery returns**
	Late Fall-run Chinook Salmon	Spawning escapement, hatchery marking, hatchery returns
	Winter-run Chinook Salmon	Hatchery marking, hatchery returns
Butte Creek	Fall-run Chinook Salmon	**Spawning escapement**
	Spring-run Chinook Salmon	**Snorkel survey**
Clear Creek	Fall-run Chinook Salmon	**Spawning escapement**
Deer Creek	Fall-run Chinook Salmon	**Spawning escapement**
	Spring-run Chinook Salmon	**Snorkel survey**
Feather River	Fall-run Chinook Salmon	**Spawning escapement**, hatchery marking, **hatchery returns, in-river harvest**
Merced River	Fall-run Chinook Salmon	**Spawning escapement**, hatchery marking, **hatchery returns**
Mill Creek	Fall-run Chinook Salmon	**Spawning escapement**
	Spring-run Chinook Salmon	Ladder counts
Mokelumne River	Fall-run Chinook Salmon	**Ladder counts**, hatchery marking, **hatchery returns**, in-river harvest
Sacramento River	Fall-run Chinook Salmon	**Ladder counts, spawning escapement, aerial redd counts, in-river harvest**
	Late Fall-run Chinook Salmon	Aerial redd counts, in-river harvest
	Winter-run Chinook Salmon	**Ladder counts, spawning escapement, aerial redd counts**
	Spring-run Chinook Salmon	**Ladder counts**
San Joaquin River	Fall-run Chinook Salmon	In-river harvest
Stanislaus River	Fall-run Chinook Salmon	**Spawning escapement**
Tuolumne River	Fall-run Chinook Salmon	**Spawning escapement**
Yuba River	Fall-run Chinook Salmon	**Spawning escapement, in-river harvest**
Pacific Ocean	Fall-run Chinook Salmon	**Ocean harvest**
	Late Fall-run Chinook Salmon	Ocean harvest
	Winter-run Chinook Salmon	Ocean harvest
	Spring-run Chinook Salmon	Ocean harvest
Steelhead Trout		
Battle Creek	Steelhead Trout	Hatchery marking, **hatchery returns**
Sacramento River	Steelhead Trout	In-river harvest
Striped Bass		
Sacramento-San Joaquin Delta and Rivers	Striped bass	Mark-recapture program every other year
American Shad		
Sacramento-San Joaquin Delta	American Shad	**Midwater trawl survey: juvenile abundance index**
White Sturgeon		
Sacramento-San Joaquin Delta	White Sturgeon	**Mark-recapture program for 2 years, followed by 2 non-estimate years**
Green Sturgeon		
Sacramento-San Joaquin Delta	Green Sturgeon	**Estimate based on ratio of Green to White Sturgeon observed during tagging**

*Programs in bold type were implemented by the end of 1997. These programs and their results for 1995 through 1997 are included in this report.

TABLE 2
CAMP: Recommended Juvenile Salmon Monitoring Program*

Recommended Watershed	Recommended Chinook Salmon Race	Watersheds/Years Included in This Report
American River	**Fall-run**	**1996, 1997**
Battle Creek	Fall-run	
Butte Creek	Fall and spring-run	
Clear Creek	Fall-run	
Deer Creek	Fall and spring-run	
Feather River	**Fall-run**	**1996**
Merced River	Fall-run	
Mill Creek	Fall and spring-run	
Mokelumne River	**Fall-run**	**1995, 1996, 1997**
Stanislaus River	**Fall-run**	**1996, 1997**
Tuolumne River	Fall-run	
Upper Sacramento River	Fall and winter-run	
Yuba River	Fall-run	

*Programs in bold type are included in this report.

To achieve CAMP's first goal, it is necessary to implement the recommended constant fractional marking program for hatchery-produced chinook salmon in the Central Valley. This program is needed to better assess progress toward meeting AFRP production goals by improving estimates of the contribution of hatchery fish to total adult chinook salmon production. A workshop to discuss a hatchery marking program was conducted with agency and stakeholder representatives on October 2, 1997. Implementation of this program should be planned in 1998.

To achieve CAMP's second goal, key environmental variables that may affect juvenile abundance, independently of actions, must be examined. Flow, temperature, and turbidity measurements have been compiled as part of the juvenile monitoring program for each of the streams shown in Table 2.

Also important for CAMP's second goal is the implementation of a standardized, site-specific, short-term monitoring program to evaluate the effectiveness of individual restoration actions. The AFRP has begun planning this monitoring program. Program implementation will provide critical information in the overall evaluation of the relative effectiveness of restoration actions analyzed as part of the CAMP juvenile monitoring program.

Implementation of CAMP through 1997

As shown in Tables 1 and 2, not all of the recommended CAMP programs were implemented by the end of 1997. In this report, we present the results of monitoring programs conducted from 1995 through 1997 that follow the basic CAMP Implementation Plan protocols (USFWS 1997a). Data are presented for all target CAMP species. Specific deviations from the Implementation Plan protocols are discussed in the appropriate sections below.

2. Adult Fish Monitoring Program: 1995 - 1997

AFRP Production Targets

The AFRP established watershed-specific restoration targets for chinook salmon and system-wide targets for all five species of anadromous fish monitored by CAMP. Not all streams for which restoration goals were established for fall-run chinook salmon are included in the CAMP monitoring program. Watersheds were selected that represent 97 percent of the total fall-run chinook production (CAMP Implementation Plan). Therefore, the CAMP production target for fall-run chinook is slightly lower than the overall AFRP target.

Adult Abundance Estimates: 1995 - 1997

Chinook Salmon

Estimates of Natural Production

Estimates of the abundance of naturally produced adult chinook salmon in monitoring years 1995, 1996, and 1997 are shown in Tables 3, 4, and 5, respectively. These estimates are based on the same assumptions used by the AFRP program to establish the 1967 -1991 baseline estimates (USFWS 1995). Estimates of adult spawners were made following the methods outlined in the CAMP Implementation Plan (USFWS 1997a). Estimates of total natural production were made for each watershed by summing all harvest and spawner abundance estimates of adult salmon and multiplying by an estimate of the proportion naturally produced. The 1995 - 1997 monitoring data included limited hatchery return data and little information on the abundance of adults of hatchery origin (see Tables 3, 4, and 5), making direct estimation of naturally produced adults impossible. In the future, estimates of the contribution of hatchery production can be refined through a constant fractional marking program for chinook salmon at Central Valley hatcheries.

The Working Paper on Restoration Needs (USFWS 1995) presented restoration goals for chinook salmon. The California Department of Fish and Game (CDFG) (1994) estimated baseline populations of anadromous fish for 1967-1991 and estimated the proportion of natural to total adults for each watershed and race. These proportions of naturally spawning fall-run fish in each watershed, shown in the far right columns of Tables 3, 4, and 5, were used in the CAMP calculations presented in this report. Spring and winter-run salmon are assumed to be naturally produced in this report. Late fall-run are assumed to be incorporated in the fall-run totals.

Estimates of total production were made by summing escapement totals (carcass counts or ladder counts), hatchery returns, in-river harvest numbers, and ocean harvest numbers. Total production numbers are then multiplied by the percent natural production estimated by CDFG (1994) to yield watershed and race-specific natural production estimates. Note that as the total production in each watershed changes from year to year the overall total percentage natural production changes accordingly (54 percent, 57 percent, and 55 percent for 1995, 1996, and 1997, respectively, see Tables 3, 4, and 5).

TABLE 3
1995 Chinook Salmon Adult Production Estimates

	Carcass Counts		Hatchery Returns						
Watershed	Total	Hatchery Component	Total	Hatchery Component	In-River Harvest	Ocean Harvest(1)	Total Production	Natural Production	% Natural (2)
Fall-Run Chinook Salmon									
American River	70,096		6,498	6,498	5,961	198,478	281,033	174,240	62%
Battle Creek	56,515		26,677	26,677		200,009	283,201	28,320	10%
Butte Creek	445 (3)					1,070	1,515	1,212	80%
Clear Creek	9,298					22,354	31,652	25,322	80%
Deer Creek	NC					1,356 (4)	1,920	1,536	80%
Feather River	59,893		11,719	11,719	3,589	180,798	255,999	156,159	61%
Merced River	1,958	1,596	602	366		6,155	8,715	7,930	91%
Mill Creek	NC					3,642 (4)	5,157	4,177	81%
Mokelumne River	7,775 (5)	3,883	3,883	3,883		21,013	29,753	24,100	60%
Sacramento River	130,653 (5)	26,677			9,066	335,911	448,953	282,841	63%
Stanislaus River	611	439				1,469	1,641	1,641	100%
Tuolumne River	743	153				1,786	2,376	2,376	100%
Yuba River	14,561				532	36,286	51,379	51,379	100%
Total	**352,548**	**32,748**	**49,379**	**49,143**	**19,148**	**1,010,328**	**1,403,295**	**761,234**	**54%**
Late-Fall Run Chinook Salmon									
Battle Creek			**1,337**	**1,337**		**3,214**	**4,551**		
Winter-Run Chinook Salmon									
Sacramento River	**1,361**					**3,272**	**4,633**	**4,633**	
Spring-Run Chinook Salmon									
Butte Creek	1,290 (6)					3,101	4,391	4,391	
Deer Creek	1,295					3,113	4,408	4,408	
Mill Creek	320	220				1,298	1,618	1,398	
Sacramento River	363 (7)					873	1,236	1,236	
Total	**3,268**	**220**				**8,386**	**11,654**	**11,434**	
Total 1995 Chinook Salmon Natural Production of Adults: 777,300									

NC = Not counted
(1) = individual watershed totals based on carcass count proportions
(2) = watershed-specific % natural versus hatchery component from CDFG (1994)
(3) = one day survey; probable underestimate
(4) = estimate based on historical percentage of fall-run returns
(5) = ladder counts
(6) = live fish and carcass survey; underestimate by approximately 200 fish
(7) = ladder count, other spring-run counts are snorkel surveys

TABLE 4
1996 Chinook Salmon Adult Production Estimates

	Carcass Counts		Hatchery Returns						
Watershed	**Total**	**Hatchery Component**	**Total**	**Hatchery Component**	**In-River Harvest**	**Ocean Harvest(1)**	**Total Production**	**Natural Production**	**% Natural (2)**
Fall-Run Chinook Salmon									
American River	65,915		7,838	7,838	6,003	92,061	171,817	106,527	62%
Battle Creek	52,404		21,178	21,178		84,934	158,516	15,852	10%
Butte Creek	500(3)					577	1,077	862	80%
Clear Creek	5,922					6,836	12,758	10,206	80%
Deer Creek	NC					621 (4)	1,159	927	80%
Feather River	46,301		8,710	8,710	3,229	67,225	125,465	76,534	61%
Merced River	4,599	2,921	1,141	733		6,626	12,366	11,253	91%
Mill Creek	NC					1,668 (4)	3,113	2,521	81%
Mokelumne River	5,417 (5)	3,323	3,323	3,323		13,457	22,197	17,979	60%
Sacramento River	119,347 (5)	21,178			4,585	143,053	245,807	154,858	63%
Stanislaus River	168	119				194	243	243	100%
Tuolumne River	3,602	2,147				4,158	5,613	5,613	100%
Yuba River	27,520				920	32,828	61,268	61,268	100%
Total	**336,036**	**30,248**	**42,125**	**41,157**	**14,737**	**454,237**	**821,398**	**464,642**	**57%**
Late-Fall Run Chinook Salmon									
Battle Creek			**4,578**	**4,578**		**5,284**	**9,862**		
Winter Run Chinook Salmon							8 hatchery returns		
Sacramento River carcass counts of 820, aerial redd counts of 940, and ladder counts of 948						**1,094**	**2,042**	**2,034**	
Spring-Run Chinook Salmon									
Butte Creek	635 (6)					733	1,368	1,368	
Deer Creek	614					709	1,323	1,323	
Mill Creek	252	152				466	718	566	
Sacramento River	326 (7)					376	702	702	
Total	**1,675**					**2,284**	**4,111**	**3,959**	
Total 1996 Chinook Salmon Natural Production of Adults: 470,635									

NC = Not counted
(1) = individual watershed totals based on carcass count proportions
(2) = watershed specific % natural component from CDFG (1994)
(3) = probable underestimate
(4) = estimate based on historical percentage of fall-run returns
(5) = ladder counts
(6) = live fish and carcass survey
(7) = ladder count, other Spring-run counts are snorkel surveys

TABLE 5
1997 Chinook Salmon Adult Production Estimates

	Carcass Counts		Hatchery Returns						
Watershed	**Total**	**Hatchery Component**	**Total**	**Hatchery Component**	**In-River Harvest**	**Ocean Harvest(1)**	**Total Production**	**Natural Production**	**% Natural (2)**
Fall-Run Chinook Salmon									
American River	56,000		6,142	6,142	4,651	86,949	153,742	95,320	62%
Battle Creek	50,743		50,670	50,670		132,017	233,430	23,343	10%
Butte Creek	800(3)					1,041	1,841	1,473	80%
Clear Creek	8,569					11,155	19,724	15,779	80%
Deer Creek	1,203					1,566	2,769	2,215	80%
Feather River	38,193		15,066	15,066	3,523	73,917	130,699	79,927	61%
Merced River	2,342		946	248		4,280	7,568	6,887	91%
Mill Creek	580					755	1,335	1,081	81%
Mokelumne River	10,163 (4)	6,494	6,494	6,494		21,684	31,847	19,108	60%
Sacramento River	223,355 (4)	50,670			9,066	302,560	484,311	305,116	63%
Stanislaus River	1,642					2,138	3,780	3,780	100%
Tuolumne River	6,096					7,936	14,032	14,032	100%
Yuba River	25,778				1,031	34,899	61,708	61,708	100%
Total	**425,464**	**57,164**	**79,332**	**27,964**	**18,271**	**680,897**	**1,146,786**	**629,569**	**55%**
Late-Fall Run Chinook Salmon									
Battle Creek			**3,069**	**3,069**		**3,995**	**7,064**		
Winter Run Chinook Salmon									
Sacramento River carcass counts of 2,053, ladder counts of 841						**2,673**	**4,726**	**4,726**	
Spring-Run Chinook Salmon									
Butte Creek	1,400 (5)					1,822	3,222	3,222	
Deer Creek	466					607	1,073	1,073	
Mill Creek	200					260	460	460	
Sacramento River	189 (4)					246	435	435	
Total	**2,255**					**2,936**	**5,191**	**5,191**	
Total 1997 Chinook Salmon Natural Production of Adults: 639,486									

(1) = individual watershed totals based on carcass count proportions
(2) = watershed-specific % natural component from CDFG (1994)
(3) = low estimate
(4) = ladder count
(5) = live fish and carcass survey

Where returning spawners were counted at a fish ladder (Mokelumne River, upper Sacramento River), and fish were later counted as entering the hatchery upstream of the ladder, the hatchery return fish were subtracted from the ladder counts so that fish were not counted twice in the total production number.

Watershed-specific ocean harvest numbers for fall-run adults were estimated from the fall-run ocean harvest totals for Central Valley stocks, as shown in USFWS (1995). The total fall-run ocean harvest was multiplied by the watershed-specific proportion of the total escapement to yield the watershed-specific ocean harvest estimate. The ocean harvest components for late fall-run, spring-run, and winter-run fish were estimated as the proportion of returning spawners of those races to the returning chinook total, multiplied by the ocean harvest total. As discussed above, the ocean harvest totals were added to other components of adult production to yield total production per watershed and race.

In-river harvest estimates were only available for a few watersheds for 1995 through 1997. For this reason, the total in-river harvest numbers were probably underestimated, as were the subsequent total and natural production numbers. Downstream harvest numbers (from the Sacramento- San Joaquin Delta) were unavailable for these monitoring years.

The hatchery marking and recovery program was inadequate to estimate the numbers of hatchery versus naturally spawning late fall-run, winter-run, and spring-run chinook salmon. Estimates of naturally spawning late fall-run chinook were not available for these monitoring years (Tables 3, 4, and 5). The highest of the redundant numbers for winter-run spawners (aerial redd counts, carcass counts, and ladder counts for Sacramento River fish) were added to the totals from other races to yield a total for chinook salmon (Tables 4 and 5). Carcass count fish identified as being of hatchery origin were subtracted from the spring-run totals (Tables 3 and 4).

Progress Toward Meeting AFRP Production Targets

Fall-Run Chinook

Table 6 compares watershed-specific targets for fall-run chinook salmon with estimates of natural production by watershed for 1995 through 1997.

TABLE 6
Fall-Run Chinook Salmon
AFRP Baseline Production Estimates, CAMP Production Targets, and Estimates of Natural Production for 1995 through 1997

Watershed	AFRP Baseline Production Estimates	CAMP Production Targets	Estimate of Natural Production		
			1995	1996	1997
American River	81,000	160,000	174,240	106,527	95,320
Battle Creek	5,000	10,000	28,320	15,852	23,343
Butte Creek	760	1,500	1,212	862	1,473
Clear Creek	3,600	7,100	25,322	10,206	15,779
Deer Creek	760	1,500	1,536	927	2,215
Feather River	86,000	170,000	156,159	76,534	79,727
Merced River	9,000	18,000	7,930	11,253	6,887
Mill Creek	2,100	4,200	4,177	2,521	1,081
Mokelumne River	4,700	9,300	24,100	17,979	19,108
Sacramento River	120,000	230,000	282,841	154,858	305,116
Stanislaus River	11,000	22,000	1,641	243	3,780
Tuolumne River	19,000	38,000	2,376	5,613	14,032
Yuba River	33,000	66,000	51,379	61,268	61,708
Total	**370,000**	**737,600**	761,234	**464,642**	**629,569**

In 1995, the total estimate of natural production of fall-run chinook salmon in streams included in the CAMP program (761,234) exceeded the total CAMP production target for that race (737,600)(Table 6). For several streams, the American River, Battle Creek, Clear Creek, Deer Creek, Mokelumne River, and the upper Sacramento River, watershed-specific natural production targets for fall-run chinook were exceeded in 1995.

In 1996, the total estimate of natural production of fall-run chinook in streams included in the CAMP program (464,642) was lower than in 1995 and fell below the total CAMP production target. Only in Battle Creek, Clear Creek, and the Mokelumne River were watershed-specific natural production targets exceeded in 1996.

In 1997, the total estimate of natural production of fall-run chinook in streams included in the CAMP program (629,569) was higher than for 1996, but it also fell below the overall CAMP production target. For Battle Creek, Clear Creek, Deer Creek, the Mokelumne River, and the upper Sacramento River, watershed-specific natural production targets were exceeded in 1997.

Natural production of fall-run chinook in the San Joaquin River tributaries generally was low throughout the 1995 through 1997 monitoring period. Production in these tributaries, the Stanislaus, Tuolumne, and Merced rivers, fell to extremely low levels during the drought years, and populations appear to be recovering slowly.

Natural production of fall-run chinook in the Mokelumne River, a tributary to the Delta, consistently exceeded AFRP production targets for the stream from 1995 through 1997. In Sacramento River basin streams, fall-run production also was relatively high during the monitoring period. In Battle and Clear creeks, natural production of fall-run chinook consistently exceeded AFRP production targets from 1995 through 1997.

Implementation of fishery restoration actions, in combination with favorable habitat conditions in recent years, resulted in the generally high natural production of fall-run chinook during the monitoring period.

Winter-Run Chinook

Table 7 compares the watershed-specific target for winter-run chinook salmon with estimates of natural production for 1995 through 1997. In all three years, estimates of natural production of winter-run chinook salmon in the upper Sacramento River were substantially below the AFRP production target (Table 7).

TABLE 7
Winter-Run Chinook Salmon
AFRP Baseline Production Estimate, Production Targets, and Estimates of Natural Production for 1995 – 1997

Watershed	Baseline Production Estimate	AFRP Production Target	Estimate of Natural Production 1995	1996	1997
Upper Sacramento River	54,000	110,000	4,633	2,034	4,726

Spring-Run Chinook

Table 8 compares watershed-specific targets for spring-run chinook salmon with estimates of natural production by watershed for 1995 through 1997. In all three years, the total estimate of natural production of spring-run chinook in all streams was also substantially below the overall AFRP production target. In Butte Creek, however, estimates of natural production exceeded the watershed-specific target for spring-run chinook production in both 1995 and 1997 (Table 8).

TABLE 8
Spring-Run Chinook Salmon
AFRP Baseline Production Estimates, Production Targets, and Estimates of Natural Production for 1995 – 1997

Watershed	Baseline Production Estimate	AFRP Production Target	Estimate of Natural Production 1995	1996	1997
Butte Creek	1,000	2,000	4,391	1,368	3,222
Deer Creek	3,300	6,500	4,408	1,323	1,073
Mill Creek	2,200	4,400	1,398	566	460
Sacramento River	29,000	59,000	1,236	702	435
Total	**35,500**	**71,900**	11,434	**3,959**	5,191

Steelhead Trout

Adult production totals are not available for this species for the 1995 through 1997 monitoring years. Steelhead in-river harvest numbers in the upper Sacramento River are required for the CAMP estimate (see Table 1) but were not available as part of the current in-river harvest estimates.

Striped Bass

Adult population estimates are made by mark/recapture in the Delta and the lower Sacramento and San Joaquin rivers. The 1996 estimate was 775,000, well below the AFRP restoration target of 2,500,000 (Table 9). Estimates for 1995 and 1997 were not available for inclusion in this report.

TABLE 9
CAMP Adult Spawner Estimates for 1995, 1996, and 1997 for Steelhead, American Shad, Striped Bass, White Sturgeon, and Green Sturgeon[1]

Monitoring Year	Species	Adult Spawner Abundance Estimate	AFRP Restoration Target
1995	Steelhead Trout	NA	13,000
	American Shad	6,859	4,300
	Striped Bass	NA	2,500,000
	White Sturgeon	NA	11,000
	Green Sturgeon	NA	2,000
1996	Steelhead Trout	NA	13,000
	American Shad	4,312	4,300
	Striped Bass	775,000	2,500,000
	White Sturgeon	NA	11,000
	Green Sturgeon	NA	2,000
1997	Steelhead Trout	NA	13,000
	American Shad	2,302	4,300
	Striped Bass	NA	2,500,000
	White Sturgeon	106,000	11,000
	Green Sturgeon	1,452 (1)	2,000

(1) Green Sturgeon = 1.37% of white sturgeon total.
NA = Not available

American Shad

Estimating methods for American shad follow those described in the CAMP Implementation Plan; these are summarized in Table 1. Monitoring results for 1995 through 1997 are shown in Table 9. Estimates of adult American shad were based on juvenile index values, which were 6,859 for 1995, 4,312 for 1996, and 2,302 for 1997 (Table 9). These results exceeded the restoration goal of 4,300 fish in 1995 and 1996 but dropped below the goal in 1997.

White Sturgeon

Estimating methods for white sturgeon were identical to those described in the CAMP Implementation Plan, as summarized in Table 1. Results are shown in Table 9. Estimates of adult spawner abundance were only available for monitoring year 1997. A total of 106,000 adult fish were estimated, exceeding the restoration goal of 11,000 (Table 9).

Green Sturgeon

Estimating methods for green sturgeon were identical to those described in the CAMP Implementation Plan, as summarized in Table 1. Results are shown in Table 9. Green sturgeon abundance was estimated as a percentage of white sturgeon numbers. The estimate was 1,452 adult fish in 1997, compared to the restoration goal of 2,000 (Table 9).

3. Juvenile Monitoring Program: 1995 - 1997

The CAMP juvenile monitoring program was established to assess the relative effectiveness of categories of CVPIA restoration actions (water management modifications, structural modifications, habitat restoration, and fish screens) toward meeting the AFRP anadromous fish production targets. In this chapter, the effects of each of these action categories on juvenile chinook salmon abundance are evaluated for the following streams and years:

- American River (1996, 1997)
- Feather River (1996)
- Mokelumne River (1995, 1996, 1997)
- Stanislaus River (1996, 1997)

The target species/race for analysis in these streams was fall-run chinook salmon. Table 10 summarizes the restoration actions implemented in recent years on these streams. Appendix A discusses restoration actions in detail. Estimated numbers of juvenile chinook emigrating from each stream are summarized in Table 11. Detailed analysis of juvenile abundance in each stream is provided in Appendix B.

TABLE 10
Summary of Restoration Actions Completed In Recent Years in the American, Feather, Mokelumne, and Stanislaus Rivers

Watershed	Year Implemented	Restoration Action Type	Action
American River	Fall 1994	Water Management	Change in flow releases from Folsom Dam
	Summer 1996	Structural Modification	Reconfigured Folsom Dam shutters
Feather River	Water years 1996, 1997, 1998	Water Management	Flows augmented in low-flow channel
Mokelumne River	1992	Water Management	Change in flow releases from Camanche Dam
	Summer/fall 1992, 1993, 1994, 1996, 1997	Habitat Restoration	Spawning gravel restoration at several sites
Stanislaus River	Spring 1995, 1996	Water Management	Flow release augmentations, April and May
	Summer 1994, 1997	Habitat Restoration	Spawning gravel restoration at several sites

TABLE 11
Summary of Estimated Numbers of Juvenile Chinook Salmon Emigrating from the American, Feather, Mokelumne, and Stanislaus Rivers, 1995 – 1997

Year	Watershed	Estimated Total Number of Young-of-the-Year Emigrating	Estimated Number of Fry < 50 mm	Estimated Number of Juveniles >50 mm
1995	Mokelumne River	434,000[1]	231,000[1]	204,000
1996	American River	4,587,000	4,462,000	125,000
	Feather River	641,000[1]	551,000[1]	91,000
	Mokelumne River	182,000[1]	102,000[1]	81,000
	Stanislaus River	105,000[1]	41,000[1]	64,000
1997	American River	1,830,000	1,773,000	58,000
	Mokelumne River	538,000[1]	393,000[1]	144,000
	Stanislaus River	47,000[1]	85[1]	47,000

[1] Potential underestimates due to late start of sampling.

The watersheds monitored to date are not markedly different in terms of completed restoration actions (Table 10). Water management modifications have been made in recent years in all four streams. Habitat restoration projects were completed at several sites in the Mokelumne and Stanislaus Rivers. One structural modification, reconfiguration of the shutters at Folsom Dam, was completed on the American River. No fish screening projects have been completed in these streams.

Restoration actions completed to date may have increased the success of chinook salmon spawning and rearing in these streams and may have resulted in a higher abundance of juveniles emigrating each winter and spring, compared to previous years. However, no trends are evident from the limited number of years of data (Table 11). Natural environmental variation, such as extreme high flows in early 1997, has reduced our ability to discern differences due to action types given the limited juvenile abundance data. In all cases, pre-project monitoring was either not available or not conducted with methods comparable to CAMP methods. In addition, sampling was not conducted over the entire fall-run emigration period in some streams and years.

The current summary of juvenile data does not lend itself to statistical interpretation. The estimates of total abundance of juvenile salmon shown in Table 11 do not indicate any obvious trends over time or among watersheds that could be attributed to the restoration actions shown in Table 10.

A comprehensive site-specific monitoring program for individual restoration actions needs to be implemented as an integral part of the CAMP juvenile monitoring program. Lacking these data, it is currently impossible to relate the magnitude of project effects to the overall juvenile production in each stream.

In future years, comparisons of abundance over time in each stream will be improved. Also, as more watersheds are included in the program, there will be a wider variety, overall, for use in comparing and evaluating restoration actions implemented.

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Appendix A

CAMP Juvenile Monitoring Program: Effects of Restoration Actions on Abundance of Juvenile Chinook Salmon at Emigration

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Appendix A: CAMP Juvenile Monitoring Program: Effects of Restoration Actions on Abundance of Juvenile Chinook Salmon at Emigration

This appendix provides the detailed methods and results summarized in Section 3 of the 1997 CAMP Annual Report. The appendix includes a documentation of the AFRP actions implemented in each of the watersheds for which juvenile salmon emigration data were available. The categories of actions are:

- Water Management Modifications
- Habitat Restoration
- Structural Modifications
- Fish Screens

Restoration actions in the first three action categories have been implemented for the watersheds for which juvenile salmon monitoring data are included in this report. Data for only a limited number of restoration actions precludes definitive conclusions regarding the effectiveness of action categories for this first report. In the future, as more watersheds with restoration actions in the four categories are monitored over more years, it is likely that relationships between juvenile success and restoration actions will become apparent.

Water Management Modifications

CVPIA-related and other water management modifications have been made in recent years in each of the streams included in the juvenile monitoring analysis in this report (American, Feather, Mokelumne, and Stanislaus rivers).

American River

On the lower American River, flow releases from Folsom Dam have been modified in recent years. In 1990, the Hodge decision set flow standards that must be met before the East Bay Municipal Utility District (EBMUD) can divert water from the lower American River. Since 1995, the CDFG, the U. S. Bureau of Reclamation (USBR), and the County of Sacramento have been working to develop operating criteria for the Folsom Project that optimize conditions for salmon spawning, rearing, and emigration. This group meets monthly to discuss real-time water management issues with the goal of providing suitable habitat for fish and wildlife.

The AFRP develops annual flow recommendations for the lower American River. The flow schedule varies releases in the fall, winter, and early spring in the lower American River between years depending on hydrologic conditions. Since 1993, higher flow releases have been made in the fall months to benefit salmonid spawning and egg incubation.

Evaluation of the effects of the new flow targets on salmon abundance is difficult without data over a long time period, due to the annual variation in flow releases. In addition, juvenile data collected prior to the flow changes did not use techniques comparable to the current studies. As a consequence, there is no reliable relationship between the water management modifications and juvenile abundance.

Feather River

On the Feather River, flows in the low flow channel between the Thermalito Diversion Dam and Thermalito Outlet were augmented in water years 1996, 1997, and 1998 to increase available chinook salmon spawning and rearing habitat. The base flow release in the channel prior to augmentation was 600 cubic feet per second (cfs). Between October 1, 1995, and January 15, 1996, flow releases in the channel were increased to 1,600 cfs. Between October 15, 1996, and January 15, 1997, flow releases were again increased to 1,600 cfs, although from mid-December on higher flood releases were made. Between October 15, 1997, and February 28, 1998, flows were 900 cfs, with some flood releases in February. For the next 2 years, flows will be returned to the 600 cfs release, and spawning use will be monitored under the typical flow regime.

Monitoring results during augmented flow periods have indicated significant salmon spawning use in the low flow channel. However, data are not yet available for comparison of spawning use under typical flow conditions. Juvenile data are available only for the spring of 1996 on the lower Feather River, following the first season of increased flows in the low flow channel. Further monitoring of adult and juvenile abundance will be needed to evaluate the effectiveness of the flow augmentations for this watershed.

Mokelumne River

On the Mokelumne River, in water year 1992, EBMUD voluntarily implemented the basic provisions of the Federal Energy Regulatory Commission (FERC) Principles of Agreement (EBMUD, CDFG, USFWS 1996), which included increased flow releases year-round for the benefit of fall-run chinook salmon and steelhead spawning, rearing, and emigration.

Increased flow releases due to implementation of the FERC provisions probably will result in long-term benefits to chinook salmon production in the Mokelumne River. However, consistent baseline data on juvenile abundance are not available for years prior to implementation of the new flow schedule; therefore, direct comparison of juvenile production before and after implementation of the new schedule is not possible. Evaluations of flow changes will have to be based on long-term monitoring of adult returns to the river.

Stanislaus River

On the Stanislaus River, an existing 1987 instream flow agreement between the USBR and CDFG requires the allocation of 98,300 to 302,000 acre-feet per year for fishery resources, depending on carryover storage levels in New Melones Reservoir. The CDFG submits recommended flow schedules to the USBR annually.

In 1995, the fishery flow allocation was 98,300 acre-feet; in 1996 and 1997, the allocation was 302,000 acre-feet. In April and May of 1995 and 1996, flow augmentations for fishery purposes were made through allocation of CVPIA 3406(b)(2) and (b)(3) water and water releases by the Oakdale and South San Joaquin Irrigation Districts. In 1997, additional flood releases were made.

Evaluation of the effects of flow changes in recent years is difficult, because flow allocations for fishery purposes vary between years, based on variations in hydrology, and releases are made to the lower river to meet many other needs. Flow augmentations in the spring of 1995 and 1996 probably increased the survival of emigrating juvenile chinook, but since juvenile data for the Stanislaus River have only been collected using standardized techniques beginning in 1996 and 1997, it is not possible to directly evaluate the effectiveness of water management modifications in increasing juvenile production.

Habitat Restoration

Habitat restoration projects were implemented on two of the streams included in the analysis, the Mokelumne and Stanislaus rivers.

Mokelumne River

On the Mokelumne River, several salmon spawning gravel restoration projects have been implemented by EBMUD in recent years. In 1992, EBMUD placed approximately 300 cubic yards of salmon spawning gravel in the Mokelumne River in the vicinity of Murphy Creek. The project was continued over subsequent years in cooperation with the CDFG and the California Department of Parks and Recreation Habitat Conservation Fund Program. Projects have typically consisted of placing clean river gravel in known spawning areas.

In the fall of 1993, 500 cubic yards of gravel were placed at the Mokelumne River Day Use Area (MRDUA). The following year, the substrate was mechanically ripped, and another 100 cubic yards of gravel were placed at the MRDUA. In the fall of 1996, EBMUD placed over 650 cubic yards of clean river gravel at three sites, two at the MRDUA and one near Mackville Road. In 1997, 1,500 cubic yards of gravel (one- to eight-inch diameter) were placed at three sites (one at the MRDUA, one near Mackville Road, and one about a mile below Mackville Road).

Spawning gravel restoration projects in recent years have probably increased the success of chinook salmon spawning, egg incubation, and early rearing in project areas. However, comparable juvenile data are not available at the watershed scale for years prior to project implementation, making pre- and post-project comparisons difficult. Biological staff at EBMUD have been conducting site-specific monitoring at each of the gravel projects completed thus far. The number of salmon spawning redds in each restored riffle area has been monitored before and after the project and compared as a proportion of the total number of spawning redds in the lower river each year. Substrate size, intergravel permeability, dissolved oxygen, temperature, and macroinvertebrate production have also been measured at project sites before and after restoration. Results of these studies are in draft form and were not available for inclusion in this report.

Stanislaus River

On the lower Stanislaus River, two gravel restoration projects have been implemented in recent years. In 1994, three spawning riffles at RM 47.4, 50.4, and 50.9 near Horseshoe Park were reconstructed, funded by the 4-Pumps Agreement. In 1997, 1,000 tons of salmon spawning gravel were added at each of two sites in Goodwin Canyon below Goodwin Dam. One project was funded by the CDFG; one was funded by CVPIA 3406(b)(13). Phase I of the project added gravel at three sites located approximately 1/2 mile below the dam; Phase II added gravel at a site approximately 1/8 mile below the dam.

These spawning gravel restoration projects in recent years on the lower Mokelumne and Stanislaus rivers have probably increased the success of chinook salmon spawning, egg incubation, and fry emergence in project areas. However, comparable juvenile data are not available at the watershed scale for an adequate number of years prior to and following project implementation, making pre- and post-project comparisons difficult. On the Stanislaus River, post-project spawning use has been monitored by the CDFG, but comparable post-project data were not collected at all sites. Implementation of a comprehensive, standardized, site-specific monitoring program throughout the Central Valley will greatly enhance the ability to evaluate the benefits of habitat restoration actions.

Structural Modifications

Only one structural modification has been completed on the streams included in this analysis.

American River

In 1996, the shutters at Folsom Dam were reconfigured to allow better water temperature management in the lower American River. The shutters can now be operated to allow the release of cooler water in the fall months to benefit salmon spawning and egg incubation. In the fall of 1996, cooler water was released from the reservoir than would have been feasible without the project. In 1997, the shutters were not operated to reduce fall water temperatures. Cooler water was released in the summer. As a consequence, during the early spawning period in the fall of 1997, temperatures were relatively high due to the prior depletion of the cool water pool in the reservoir.

The cooler water temperatures may have increased spawning and egg incubation success in the early part of the spawning period in the fall of 1996. Direct evaluation of the effects of the project on juvenile abundance was not possible, however, because no comparable juvenile monitoring data were collected before the project was implemented. Comparisons of the effects of fall temperature conditions on juvenile abundance between the 1996 and 1997 sampling years cannot be made, because extreme high flows in the winter of 1997 may have had an adverse effect on juvenile abundance in 1997.

Fish Screens

No fish screening projects have been completed in recent years on streams included in this analysis. In future years, the effects on juvenile abundance of the installation of new screens or of upgrading existing screens will be evaluated. The current data serve as pre-screen information (as appropriate) for juvenile salmon production on the watersheds evaluated in this report. As more watersheds are brought into the CAMP juvenile salmon monitoring program, both pre-and post-screen conditions will be assessed.

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Appendix B

CAMP Juvenile Monitoring Program: Summary of Juvenile Chinook Salmon Monitoring, 1995-1997 Detailed Methods and Results

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Appendix B: CAMP Juvenile Monitoring Program: Summary of Juvenile Chinook Salmon Monitoring, 1995 – 1997, Detailed Methods and Results

Introduction

Target streams for the CAMP juvenile monitoring program were selected based on the presence of target races, opportunities to spatially isolate the effects of actions, the implementation schedule for restoration actions, and the presence of existing juvenile and adult monitoring programs. Target streams for juvenile monitoring include the American River, Battle Creek, Butte Creek, Clear Creek, Deer Creek, Feather River, Merced River, Mill Creek, Mokelumne River, Stanislaus River, Tuolumne River, Sacramento River (upper mainstem), and Yuba River.

To monitor the entire period of juvenile emigration for each target race, the following sampling periods were selected. In streams with fall-run chinook salmon only, sampling was conducted from January 1 through June 30. In streams with fall and spring-run chinook, sampling was conducted from September 1 through June 30. In streams with fall, spring, and winter-run chinook (upper Sacramento River), sampling was conducted year-round.

Rotary screw traps were selected as the standard gear to sample juvenile chinook salmon abundance for the CAMP. Although rotary screw traps have been used in some Central Valley streams since 1991 to monitor juvenile salmon, sampling programs have often been under-funded, sporadic, or short-term. Implementation of the CAMP juvenile monitoring program in 1998 will provide funding for new rotary screw trap programs and establish a consistent, long-term data management and retrieval system.

A standardized protocol for rotary screw trap sampling was developed for the CAMP based on the protocols used in existing studies on the upper Sacramento River at Red Bluff (by the USFWS), the upper Sacramento River at Balls Ferry (by the CDFG), the lower Sacramento River at Knights Landing (by the CDFG), the lower American River (by the CDFG), and the lower Stanislaus River (by S.P. Cramer and Associates under contract to the USFWS).

This report provides the results of rotary screw trap sampling for fall-run chinook salmon in four streams with existing programs for the 1995 through 1997 period. These programs used methods that conformed, with some exceptions, to the standardized protocol developed for CAMP. The streams and sampling locations are included in Table B-1.

TABLE B-1
Rotary Screw Trap Programs Included in the Current CAMP Juvenile Monitoring Program Report

Watershed Name and Year of Data	Monitoring Program Name	Target Species/Race	Location of Screw Trap(s)	Monitoring Period	Lead Agency	Year Began
American River 1996, 1997	Lower American River Emigration Survey	Fall-run chinook	One trap near Watt Avenue in Sacramento	1 Jan. - 30 Jun.	CDFG	1994
Feather River 1996	Feather River Outmigration Study	Fall-run chinook	One trap at Live Oak	1 Jan. - 30 Jun.	DWR	1996
Mokelumne River 1995, 1996, 1997	Mokelumne River Chinook Salmon and Steelhead Monitoring Program	Fall-run chinook	Two traps at Woodbridge Dam	1 Jan. - 30 Jun.	EBMUD	1993
Stanislaus River 1996, 1997	Stanislaus River Juvenile (smolt) Production Indices and Estimates	Fall-run chinook	Two traps near Caswell State Park	1 Jan. - 30 Jun.	USFWS	1994

The CAMP Implementation Plan proposed a variety of qualitative and quantitative analytical techniques to evaluate juvenile abundance data, including:

- Assessment of changes in juvenile abundance within watersheds over time, both prior to and following action implementation
- Comparison of juvenile abundance among watersheds
- Integration of AFRP and other CVPIA site-specific monitoring results into the CAMP evaluation
- Use of adult spawner/juvenile abundance relationships to link the impact of actions that increase juvenile abundance to adult production
- Assessment of the effects on juvenile abundance of changes in abiotic environmental variables.
- Qualitative and quantitative assessment of the relative effectiveness of different categories of actions by assessment of results over individual watersheds

Most of these techniques require several years of data from several streams. Data from a site-specific monitoring program are not yet available. This report analyzes only the results of one to three years of sampling from four Central Valley streams, making comparisons within or among watersheds unreliable. Many of the proposed analyses, therefore, were not conducted for this report. For example, the ratio of juvenile numbers to number of adult spawners in each watershed was not calculated because, in many cases, the juvenile data were incomplete, and the ratio is sensitive to the compounded error of the adult and juvenile abundance estimates.

This report is therefore limited to the following summaries for each stream in each sampling year:

- Estimates of abundance of total young-of-the-year (YOY), fry ($\leq$ 50 millimeters [mm] fork length), and other juveniles (> 50 mm and $\leq$ 125 mm fork length) emigrating each day

- Relationship of juvenile abundance to two environmental factors, flow and water temperature, during the rearing period to evaluate the effects of key limiting factors on juvenile production
- Preliminary analysis of the effects of restoration action implementation on juvenile abundance

American River

Methods

Rotary screw traps have been used by the CDFG Stream Flow and Habitat Evaluation Program, beginning in 1992, to monitor juvenile emigration from the lower American River. The first full sampling season was in 1994. From 1992 to 1995, the study was funded by EBMUD. Since 1995, funding has been provided by the USFWS or the USBR pursuant to the CVPIA.

Methods used for rotary screw trap sampling on the lower American River were incorporated in developing the CAMP standard protocol. Therefore, sampling methods on the American River were generally consistent with the standard protocol. In 1995, however, trap efficiency tests were not conducted, precluding the calculation of abundance estimates. Therefore, the results of 1995 sampling are not included in this report.

In 1996 and 1997, a single rotary screw trap (8-foot diameter) was fished just downstream of the Watt Avenue bridge in Sacramento (RM 9). Sampling was conducted continuously from October 1995 through September 1996 and from mid-December 1996 through June 1997. Results from the standard period of fall-run chinook emigration, January 1 through June 30, 1996, and 1997 are included in this report.

Traps were fished 24 hours per day, 7 days per week, and checked once or twice daily. During each trap check, fish were removed from the trap, sorted, and counted by species. From 50 to 100 individuals of each species were sub-sampled from the start, middle, and end of each catch, for a total of 150 to 300 fish per trap catch. Sub-sampled fish were measured and weighed (fork length to the nearest 0.5 mm and weight to the nearest 0.1 g). Measured salmonids were visually classified as yolk-sac fry, fry, parr, silvery parr, or smolts. Water transparency (secchi disk depth), water temperature, and effort (hours fished since last trap check) were recorded during each trap check (CDFG 1997). Turbidity data (NTU) were obtained from the City of Sacramento Fairbairn Water Treatment Plant (RM 7). Flow data used in this report were obtained from U.S. Geological Survey (USGS) gage 11446500 at Fair Oaks, California.

Trap efficiency tests were conducted weekly from January 21 through May 6 in 1996 and from January 21 through March 24 in 1997. Fish captured in the trap were marked and released approximately 2,500 feet upstream. In 1996, fish were marked using Alcian blue dye; a specific pattern was used to indicate the week of marking. In 1997, fish were marked using a Bismark brown bath. Use of this dye enabled much larger release groups to be marked. During each efficiency test, all fish measured were also checked for marks. When all fish were not checked, the number of recovered fish was expanded by the proportion of fish checked to the total number captured. When no fish were recaptured in a test, results of the test were not used. Calculated efficiency rates (number of recaptures/number of marked fish in release group) varied from 0.00101 to 0.01217 in 1996 and from 0.00424 to 0.02399 in 1997.

Appropriate efficiency test results were applied to raw catch data on each date to estimate the number of juvenile chinook salmon emigrating on that day, by size class (estimated number = raw catch / trap efficiency rate). Results of the closest efficiency test in time were applied to catches in time periods where efficiency tests were not conducted (at the beginning and end of each trapping season). For example, results of the last efficiency test in 1997, on March 24, were applied to the remainder of the season.

Results

Estimated Abundance

The estimated daily number of fry and other juvenile YOY chinook salmon emigrating from the lower American River in 1996 and 1997 is shown in Figures B-1 and B-2, respectively.

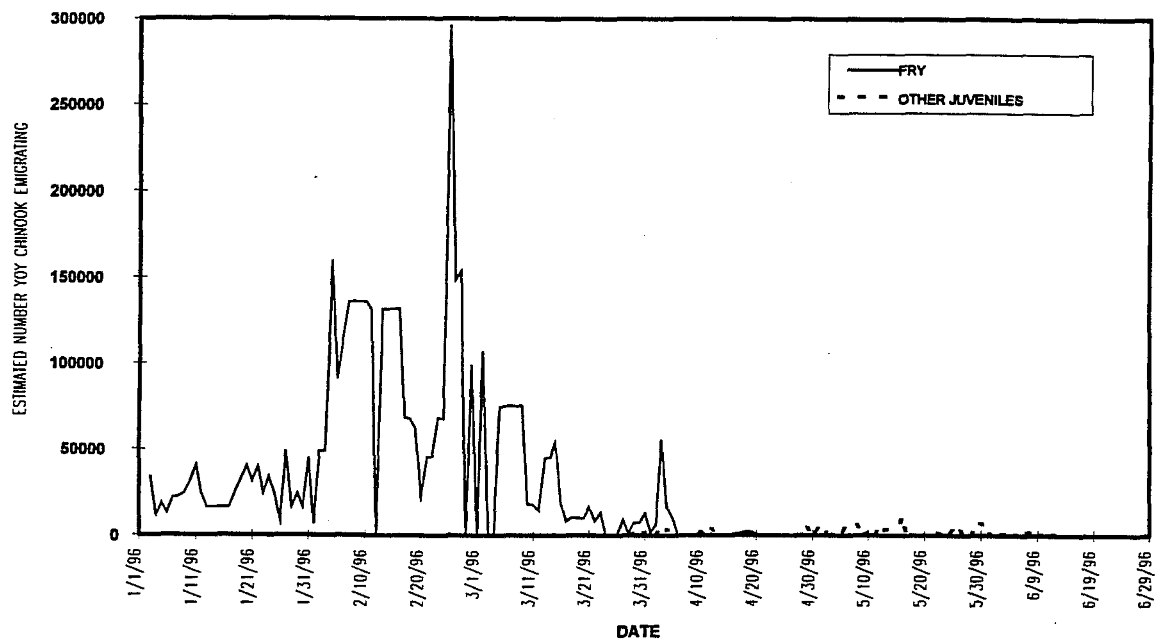

Figure B-1. Estimated Number of YOY Chinook Salmon (Fry and Other Juveniles) Emigrating from the Lower American River by Day, 1996

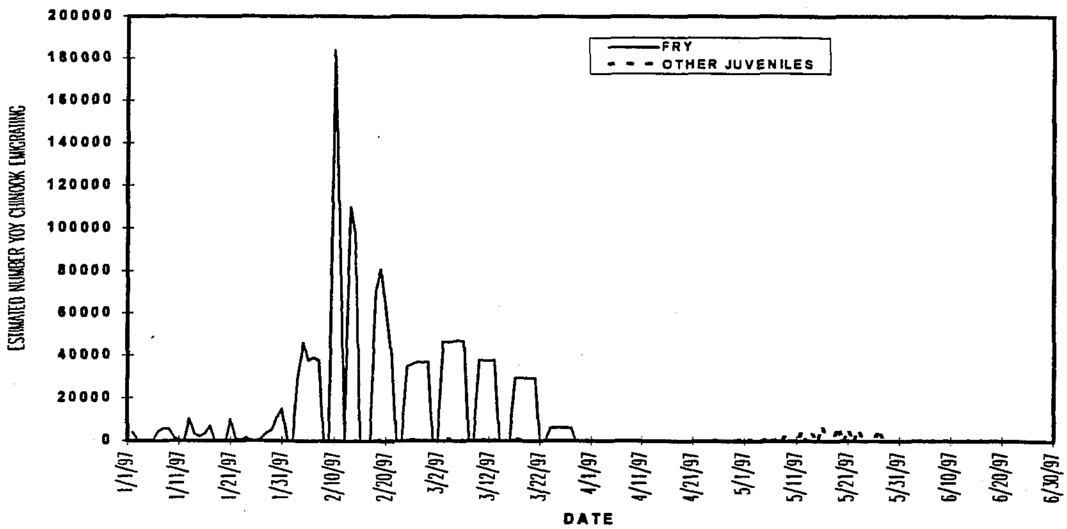

Figure B-2. Estimated Number of YOY Chinook Salmon (Fry and Other Juveniles) Emigrating from the Lower American River by Day, 1997

In both years, the majority of YOY emigrated from the lower American River as fry (97 percent in both years). In 1996, fry emigration was high throughout the month of February and peaked in late February; few fry were caught after the first week of April. The abundance of larger juveniles peaked in mid-May. The timing of emigration was similar in 1997. Fry emigration peaked in mid-February and was high throughout February and March. No fry were caught after the first week of April. The abundance of larger juveniles peaked in mid-May.

Between January 3 and June 21, 1996, an estimated 4,587,216 YOY fall-run chinook salmon emigrated from the lower American River. Of this total, an estimated 4,461,729 fish emigrated as fry less than or equal to 50 mm; an estimated 125,487 fish emigrated as juveniles greater than 50 mm and less than 125 mm.

Between January 2 and June 20, 1997, an estimated 1,830,373 YOY fall-run chinook salmon emigrated from the lower American River. Of this total, an estimated 1,772,842 fish emigrated as fry less than or equal to 50 mm; an estimated 57,532 fish emigrated as juveniles greater than 50 mm and less than 125 mm.

Relationship of Juvenile Abundance to Environmental Factors

Effect of Streamflow on Juvenile Emigration

Flow data for the lower American River were obtained from USGS gage 11446500 in Fair Oaks, California. Figure B-3 shows the mean daily flow at the gage site during the egg incubation, juvenile rearing, and emigration period in 1995 through 1996 (October 1995 through June 1996) and the abundance of YOY chinook salmon emigrating from the lower American River.

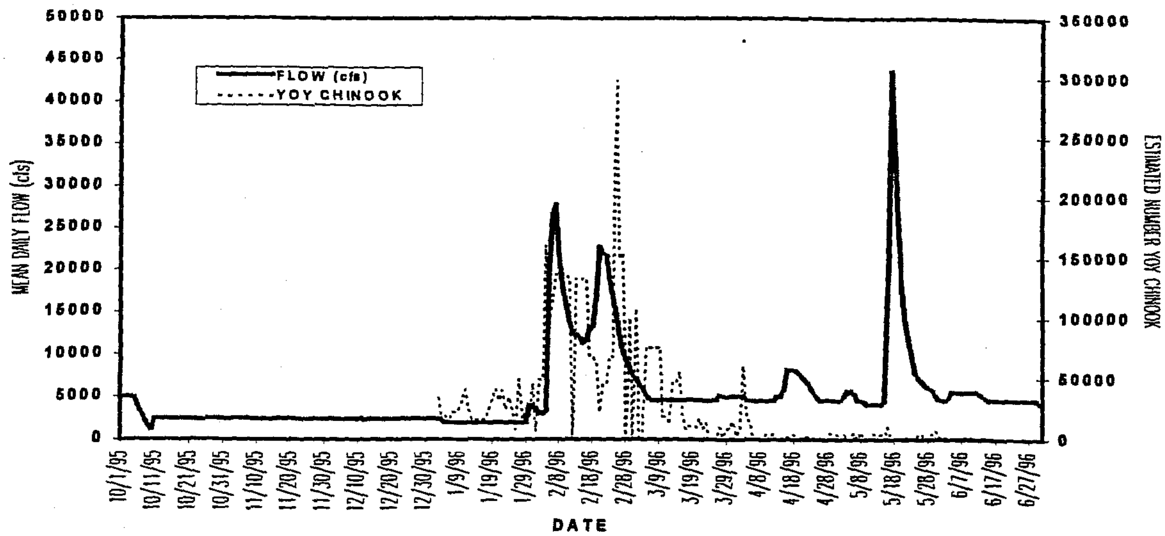

Figure B-3. Mean Daily Flow at Fair Oaks, October 1995 through June 1996, and Estimated Abundance of YOY Chinook Salmon Emigrating from the American River, 1996

Flows were relatively low and constant at 2,500 cfs from the beginning of October to the end of January. In early February 1996, flows were high and variable, peaking over 25,000 cfs. These high flows coincided with the peak fry emigration in February. Flows during March and April were relatively constant, remaining at about 5,000 cfs. Fry continued to emigrate in smaller numbers throughout March. In April, relatively low numbers of larger juveniles emigrated. In May and June, flows remained relatively constant (2,500 to 5,000 cfs) except for a one-week flow spike in late May. Larger juveniles continued to emigrate in low numbers through the end of sampling in late June.

Although the peak of fry emigration in 1996 coincided with a period of relatively high flows in February, it is not known whether the high flows stimulated emigration.

Figure B-4 shows the mean daily flow at the gage site during the egg incubation, juvenile rearing, and emigration period in 1996 through 1997 (October 1996 through June 1997) and the abundance of YOY chinook salmon emigrating in 1997. Flows throughout the spawning and early rearing period in October and November were low and relatively constant at 2,500 to 5,000 cfs. In December and January, flows increased, reaching a high of over 100,000 cfs in early January. Flows continued to be high through January and early February. From late February through the end of March, flows generally declined from a high of 7,000 cfs to about 3,000 cfs. Flows were relatively steady and declining in April, May, and June, remaining below 3,000 cfs for most of the period.

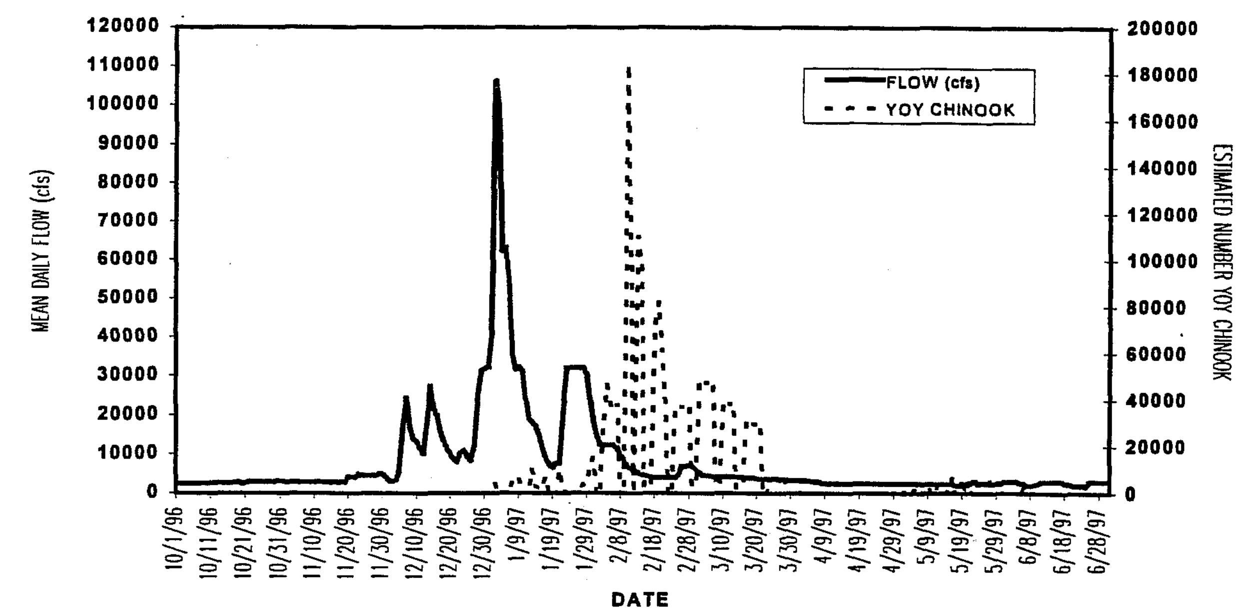

Figure B-4. Mean Daily Flow at Fair Oaks, October 1996 through June 1997, and Estimated Abundance of YOY Chinook Salmon Emigrating from the American River, 1997

In 1997, sampling was conducted through the extremely high flows in the beginning of January. High flows necessitated moving the trap to the side of the river for several days in early January to avoid a debris plume in the center of the channel, but the trap was moved back toward the thalweg of the river after the very high flow event began to recede. Numbers of fry caught were low throughout January. Fry abundance peaked in mid-February and continued to be high throughout March; abundance of larger juveniles peaked in mid-May. Neither peak appeared to correspond to changes in river flow. The timing of juvenile emigration was similar in 1996 and 1997, even though flow patterns in those years were very different.

Flows in late December and early January, 1997 were probably high enough to cause gravel movement and scouring of eggs and yolk sac fry in redds. Losses of eggs and fry may have been a factor contributing to the lower estimate of juvenile production in 1997 compared to 1996 (B. Snider, personal communication).

Effect of Water Temperature on Spawning and Egg Incubation

Water temperatures were measured by CDFG in 1995 and 1996 at Watt Avenue. From October 1 to December 19, 1995, a Ryan thermograph was employed; from December 20, 1995, to June 30, 1996, a hand-held thermometer was used.

Mean daily water temperatures from October 1995 through June 1996 are shown in Figure B-5. Temperatures during October 1995, when chinook salmon spawning and egg incubation were occurring in the river, ranged from 60.4 to 64.8° F. These temperatures exceeded the optimum temperature range for chinook salmon spawning and egg incubation (41.0 - 56.0° F) (Rich 1987; Reiser and Bjornn 1987), and were within the range reported as resulting in low to medium chronic stress for these life stages (Leidy and Li

1987). In November, temperatures ranged from 56.1 to 60.4° F, still exceeding optimum temperatures for chinook spawning and rearing. In December, temperatures ranged from 51.0 to 57.2° F.

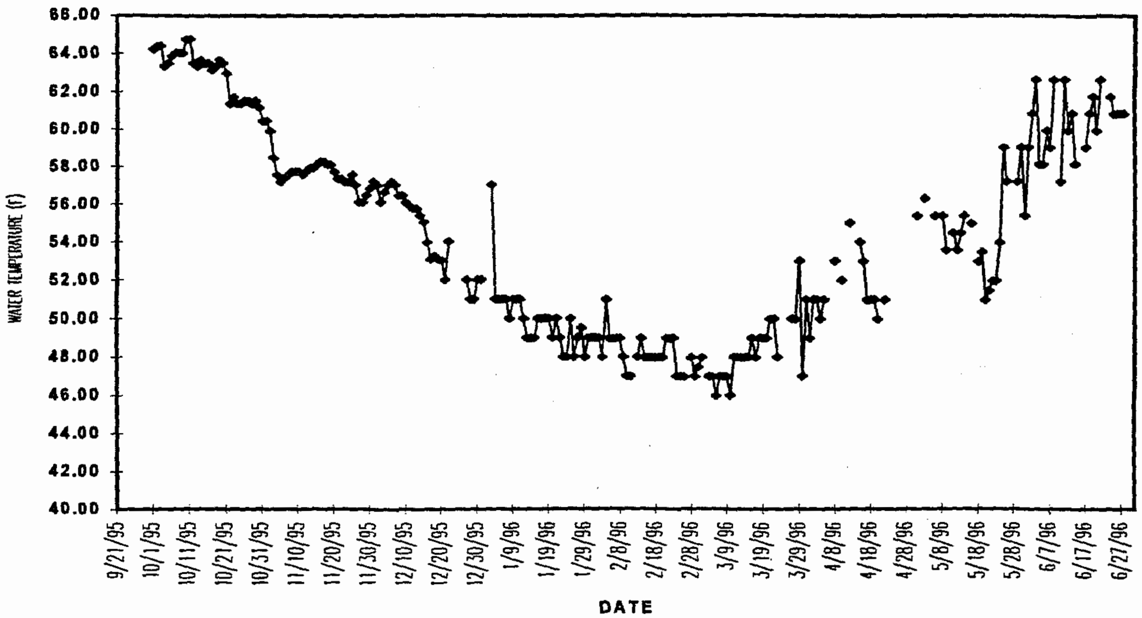

Figure B-5. Mean Daily Water Temperature at Watt Avenue on the Lower American River, October 1995 through June 1996

Water temperatures were measured by CDFG at Watt Avenue or Nimbus Dam between 1996 and 1997. From October 2, 1996, to January 31, 1997, a Stowaway recorder was used to measure water temperature at Nimbus Dam. From February 1 to June 30, 1997, a Stowaway recorder was used at Watt Avenue. Mean daily water temperatures from October 1996 through June 1997 are shown in Figure B-6.

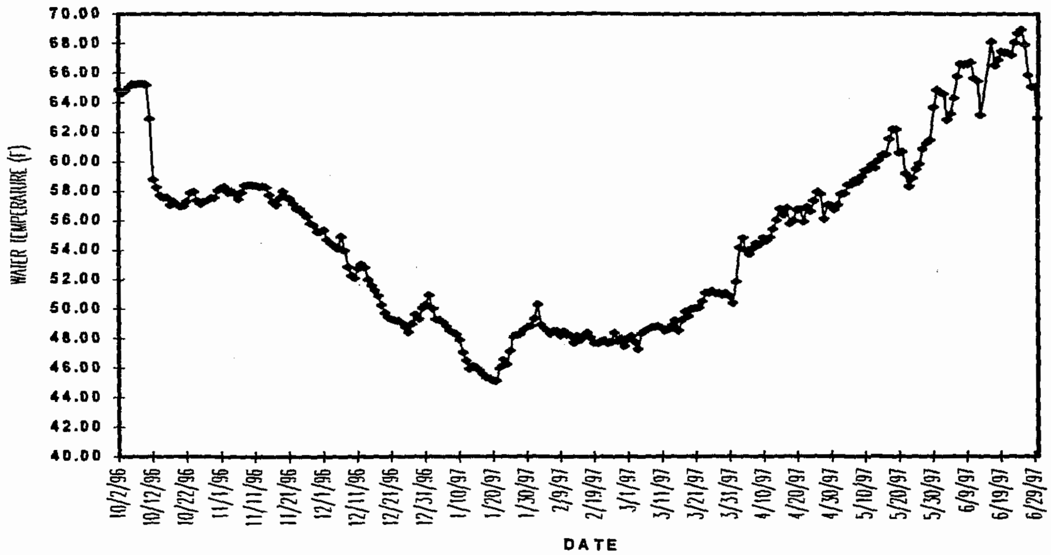

Figure B-6. Mean Daily Water Temperature at Watt Avenue or Nimbus Dam on the Lower American River, October 1996 through June 1997

In the fall of 1996, reconfigured shutters at Folsom Dam were operated to release cooler water to benefit salmon spawning and egg incubation. Temperatures during early October 1996 were relatively high, ranging from 62.9 to 65.3° F. From October 12 through the end of the month, temperatures dropped to between 57.0 and 58.8° F; the temperatures still exceeded optimum temperatures for chinook spawning and egg incubation, but they were much lower than in October of 1995. In November 1996, temperatures ranged from 55.2 to 58.3, which was lower than in November of 1995.

Feather River

Methods

In cooperation with the CDFG, the Department of Water Resources (DWR) has initiated numerous fishery studies on the lower Feather River. Many of the study elements are included in the recent draft CVPIA plan to restore anadromous fish. Juvenile emigration data are collected by DWR Environmental Services staff based at the Oroville Field Division.

Rotary screw trap sampling was conducted from March 4 to December 27, 1996, at the Live Oak site (station FR042E) on the lower river. In general, methods used for rotary screw trap sampling on the Feather River in 1996 were consistent with the CAMP standard protocol. Data from March 4 through June 30, 1996, the standard monitoring period for fall-run chinook, are included in this report. In January 1997, sampling was discontinued when flood flows washed out the trap.

In 1996, a single rotary screw trap (8-foot diameter) was fished at the Live Oak site. The trap was fished 24 hours per day, 7 days per week, and checked at least once daily. Traps were serviced more frequently during periods of peak emigration. During each trap check, fish were removed from the trap, sorted, and counted by species. Up to 50 individuals of each species were measured to the nearest 0.5 mm fork length. Water transparency (secchi disk depth), water temperature, and effort were recorded during each trap check. Flow data used in this report were obtained from the DWR gage site on the Feather River at Gridley.

One trap efficiency test was conducted on March 21, 1996, at the Live Oak site. Fish captured in the trap were marked by fin clipping (dorsal or caudal) and held in live boxes adjacent to the traps. Fish were kept for 1 to 5 days prior to release approximately 1 km upstream of each trap. The calculated efficiency rate (number of recaptures/number of marked fish in release group) was 0.0040 in 1996.

This efficiency rate was applied to raw catch data on each date to estimate the number of juvenile chinook salmon emigrating on that day by size class (estimated number = raw catch/trap efficiency rate).

Results

Estimated Abundance

The estimated daily numbers of fry and other juvenile YOY chinook salmon emigrating from the Feather River in 1996 are shown in Figure B-7.

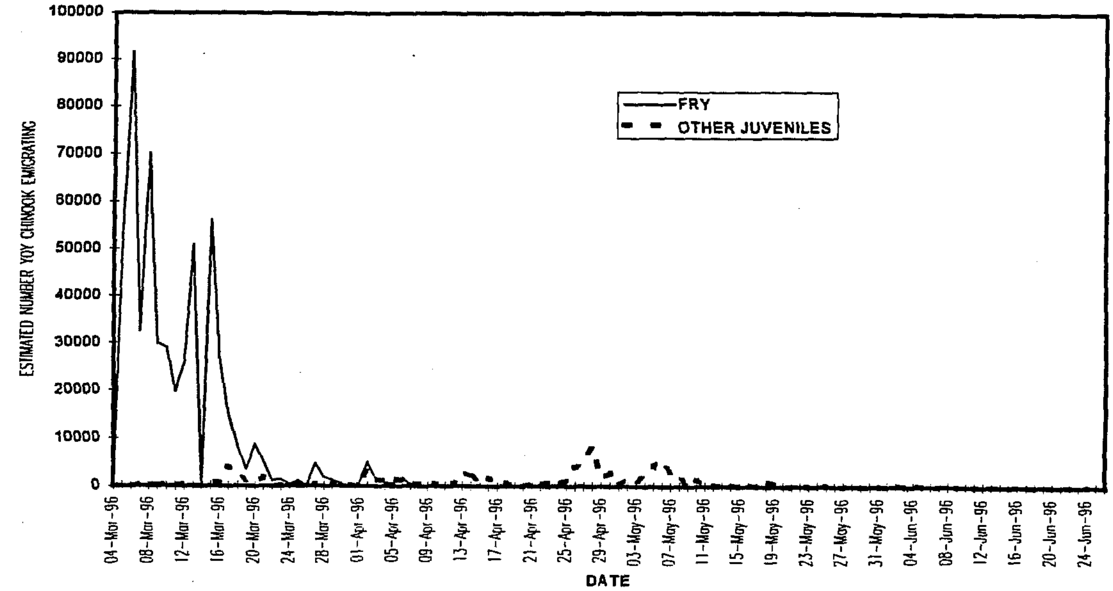

Figure B-7. Estimated Number of YOY Chinook Salmon (Fry and Other Juveniles) Emigrating from the Lower Feather River by Day, 1996

Most of the YOY chinook salmon emigrated from the river as fry in 1996. Fry abundance peaked shortly following installation of the trap on March 4. Some fry probably emigrated prior to installation of the trap. Fry abundance in general decreased throughout March and continued at low levels throughout April and May. Abundance of larger juveniles was low throughout the season; it peaked in late April and early May.

Between March 4 and June 30, 1996, an estimated 641,000 YOY fall-run chinook salmon emigrated from the Feather River. Of this total, an estimated 550,500 fish, or 86 percent emigrated as fry (less than or equal to 50 mm); an estimated 90,500 fish emigrated as larger juveniles (greater than 50 and less than 125 mm). These are probably under estimates of the abundance of fry and total YOY because sampling started late in 1996.

Relationship of Juvenile Abundance to Environmental Factors

Effect of Streamflow on Juvenile Emigration

Flow data for the Feather River were obtained from the DWR gage located at Gridley, California. Figure B-8 shows the mean daily flow at the gage site during the egg incubation, juvenile rearing, and emigration period from 1995 through 1996 (October 1995 through June 1996) and the abundance of YOY chinook salmon emigrating from the Feather River from March through June.

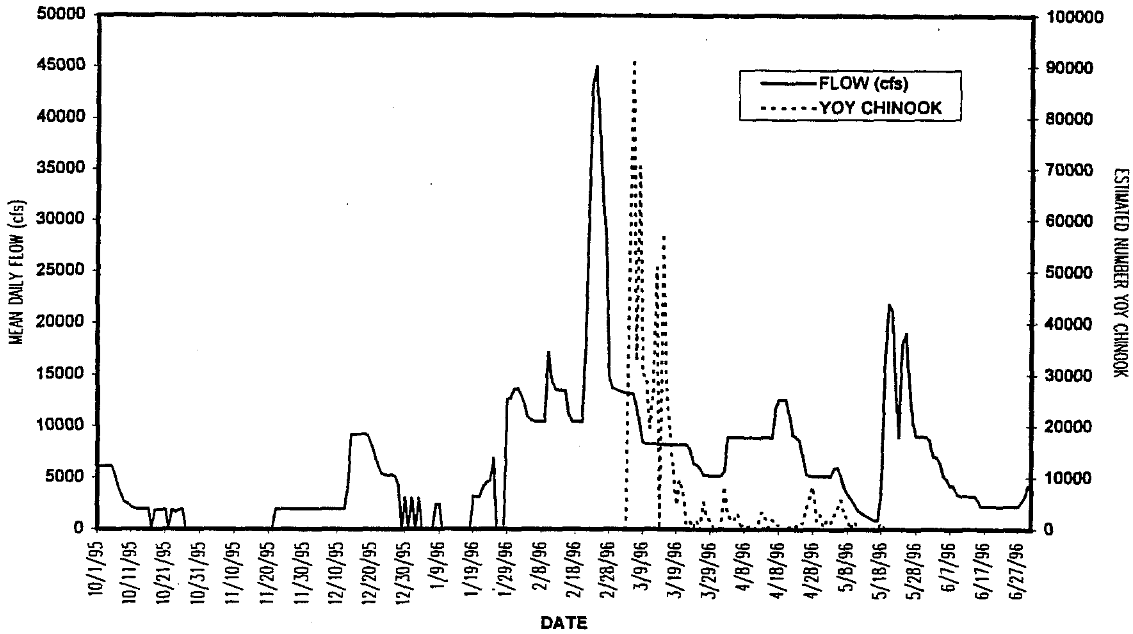

Figure B-8. Mean Daily Flow at Gridley, October 1995 through June 1996, and Estimated Abundance of YOY Chinook Salmon Emigrating from the Feather River, 1996

Flows throughout October, November, and the beginning of December were relatively low. Some fry emigration probably occurred prior to the start of sampling during higher flow periods in late December, January, and particularly in February. Flows were high throughout February, with a peak occurring in late February, just prior to the start of sampling. Both flow and fry abundance, in general, decreased between the beginning and end of March. It is unknown if flows had a significant effect on the timing of emigration. Flows again peaked in late May, but the abundance of larger juveniles was relatively low and variable throughout April and May and did not appear to be related to changes in stream flow.

Effect of Water Temperature on Spawning and Egg Incubation

Mean daily water temperatures collected at the DWR gage site on the Feather River below Thermalito Afterbay (TM5173) from October 1995 through June 1996 are shown in Figure B-9. Temperatures during October 1995 slightly exceeded optimum levels for chinook salmon spawning and egg incubation only in the first three days of the month. In the remainder of the spawning and egg incubation period, water temperatures were within the optimum range (41.0 - 56.0°F) for chinook salmon spawning and egg incubation.

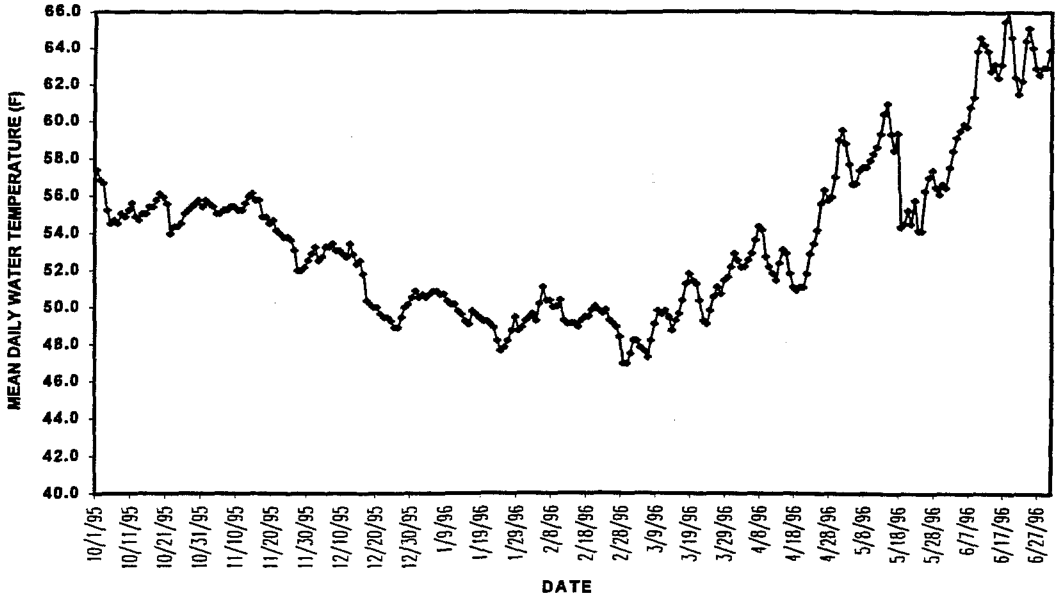

Figure B-9. Mean Daily Water Temperature, Feather River below Thermalito Afterbay, October 1995 through June 1996

Mokelumne River

Methods

Since 1993, Natural Resource Scientists, Inc., under contract with EBMUD, has used rotary screw traps to monitor juvenile emigration on the lower Mokelumne River. In general, methods used for rotary screw trap sampling on the lower Mokelumne River have been consistent with the CAMP standard protocol. Data from the 1995, 1996, and 1997 sampling seasons are included in this report.

Two rotary screw traps (8-foot diameter) were fished side-by-side each year immediately downstream from Woodbridge Dam. Sampling was conducted continuously from January 25 through July 28, 1995, from January 15 through July 30, 1996, and from January 30 through June 24, 1997. Because emigrating juvenile fall-run chinook salmon are the target race for the Mokelumne River in the CAMP analysis, results from the standard period for fall-run chinook emigration, with sampling from January through June, are included in this report.

Traps were fished 24 hours per day, 7 days per week, and checked at least twice daily, early in the morning and late in the afternoon. During periods of high debris loads and/or large fish catches, traps were checked two or three additional times each day. During each trap check, fish were removed from the trap, sorted, and counted by species. Up to 30 individuals of each salmonid species captured in each trapping period were randomly subsampled, measured (total length and fork length in mm), and weighed (in grams).

Water transparency (secchi disk depth in centimeters) was recorded twice daily in pool 9a of the low-stage fishway, or from the screw trap platform located about mid-channel from Woodbridge Dam, or immediately upstream of spill bay #1 in Lodi Lake. Water temperature (°F) was measured with a continuously recording thermograph located in pool #8a in the low-stage fishway. Trap revolutions were recorded during each trap check. Flow data for the Mokelumne River were obtained from USGS gage 11323500 located below Camanche Dam.

Paired day and night trap efficiency tests were conducted frequently throughout the sampling period each year. Fish were obtained from the Mokelumne River Fish Hatchery. Fish were marked by excision of the pelvic fin or clipping a portion of the upper or lower lobes of the caudal fin and were allowed to recover for 8 to 24 hours prior to release. Releases were made approximately 20 to 30 meters upstream of the trap site. During each efficiency test, all fish were measured and checked for marks. Calculated efficiency rates (number of recaptures/number of marked fish in release group) varied from 0.039 to 0.227 in day tests and 0.009 to 0.09 in night tests in 1995, from 0.030 to 0.170 in day tests and 0.020 to 0.120 in night tests in 1996, and from 0.010 to 0.065 in day tests and 0.003 to 0.112 in night tests in 1997.

Day and night trap efficiency test results were applied separately to diurnal and nocturnal raw catch data on each date to estimate the number of juvenile chinook salmon emigrating (estimated number = raw catch / trap efficiency rate). Diurnal and nocturnal estimates were then summed to provide daily abundance estimates.

In the latter part of the sampling season in 1997, additional traps were used at Woodbridge Dam to sample emigrating juveniles. From April 30 through the end of July, a trap installed at the fish bypass outfall captured all fish coming through the bypass. From June 18 through the end of July, an additional incline plane trap was placed in the high-stage fishway of Woodbridge Dam. In periods when the incline plane traps were used in conjunction with rotary screw trap sampling, the estimate of emigrating juvenile chinook on each date was calculated by applying appropriate efficiency rates to rotary trap data and then summing abundance determined for each trapping site.

Results

Estimated Abundance

The estimated daily numbers of fry and other juvenile YOY chinook salmon emigrating from the Mokelumne River at Woodbridge in 1995, 1996, and 1997 are shown in Figures B-10, B-11, and B-12, respectively.

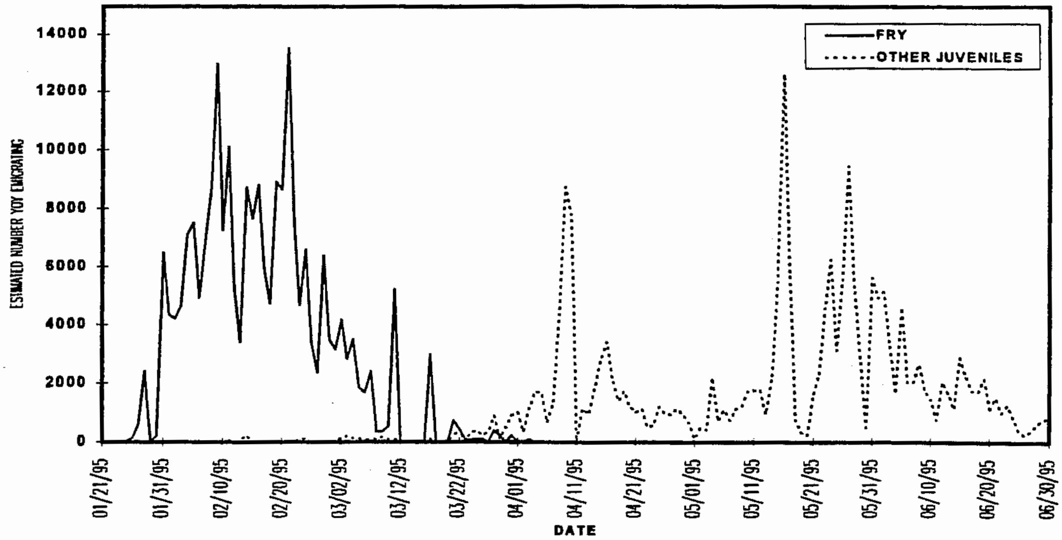

Figure B-10. Estimated Number of YOY Chinook Salmon (Fry and Other Juveniles) Emigrating from the Lower Mokelumne River by Day, 1995

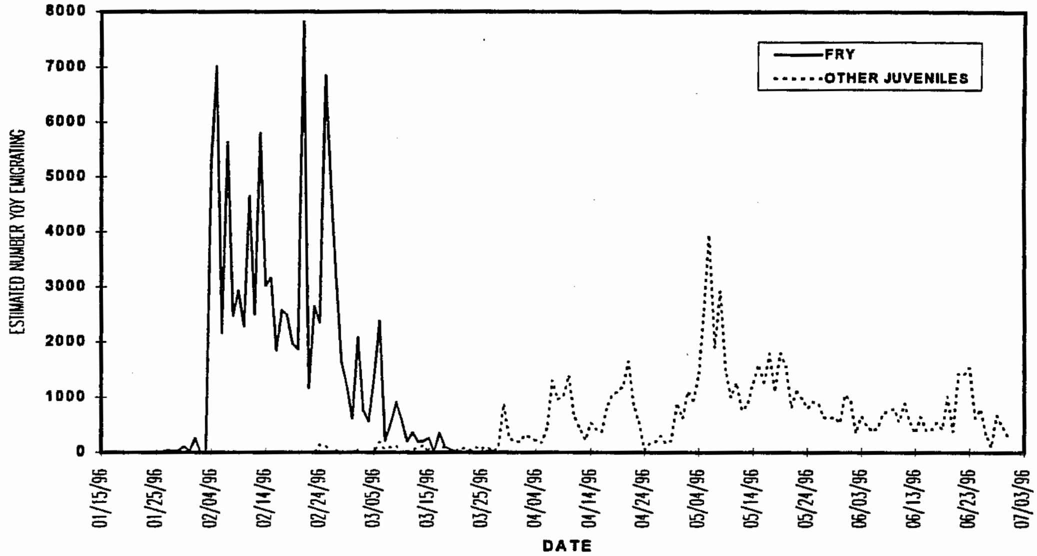

Figure B-11. Estimated Number of YOY Chinook Salmon (Fry and Other Juveniles) Emigrating from the Lower Mokelumne River by Day, 1996

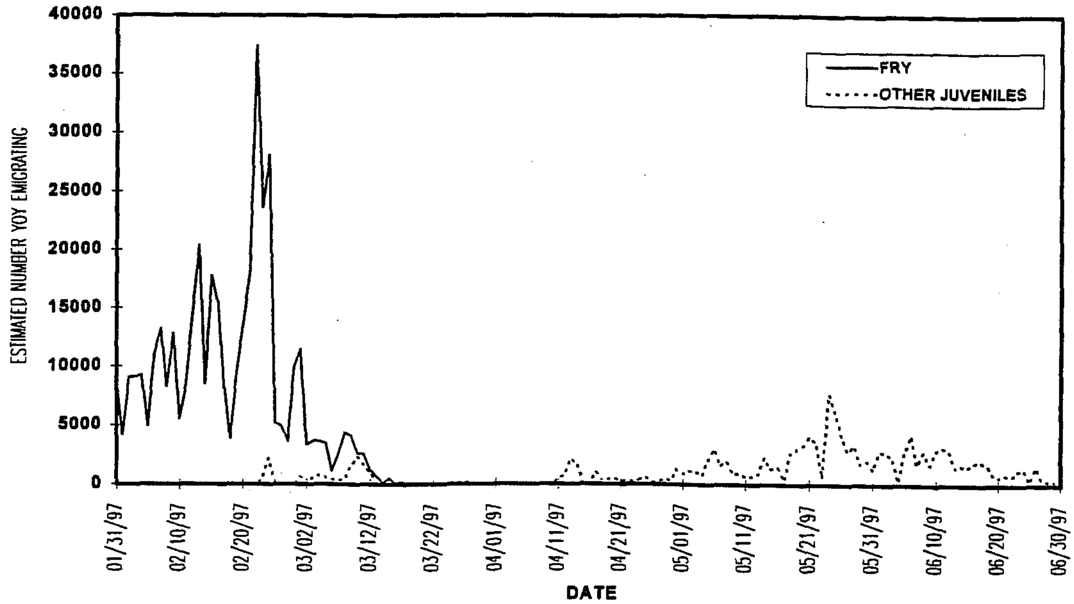

Figure B-12. Estimated Number of YOY Chinook Salmon (Fry and Other Juveniles) Emigrating from the Lower Mokelumne River by Day, 1997

In each year, the majority of YOY emigrated from the Mokelumne River as fry. The timing of emigration was similar in all three years. In 1995, fry emigration was high throughout February, peaking in mid-February; it declined through March. Emigration of larger juveniles was prolonged, peaking in mid to late April and continuing through the end of June. In 1996, fry emigration was high throughout February, peaking in late February and declining through March. No fry were caught after the end of March. The abundance of larger juveniles peaked in early May, and emigration continued through the end of June. In 1997, it appears from the pattern of emigration that some fry emigrated prior to the start of sampling in late January. Fry emigration was high throughout February, peaking in late February and declining through March. No fry were caught after the end of March. Few larger juveniles emigrated in 1997; abundance of larger juveniles extended from mid-February through the end of June, peaking in late May.

Between January 25 and June 30, 1995, an estimated 434,096 YOY fall-run chinook salmon emigrated from the lower Mokelumne River. Of this total, an estimated 230,582 fish (or 53 percent) emigrated as fry; an estimated 203,513 fish emigrated as juveniles greater than 50 mm.

Between January 15 and June 30, 1996, an estimated 182,461 YOY fall-run chinook salmon emigrated from the river. Of this total, an estimated 101,788 fish (or 56 percent) emigrated as fry less than or equal to 50 mm; an estimated 80,672 fish emigrated as juveniles greater than 50 mm and less than 125 mm.

Between January 31 and June 30, 1997, an estimated 537,713 YOY fall-run chinook salmon emigrated from the Mokelumne River. Of this total, an estimated 393,341 fish (or 73 percent) emigrated as fry less than or equal to 50 mm; an estimated 144,372 fish emigrated as juveniles greater than 50 mm and less than 125 mm.

Since monitoring periods varied between years, it is difficult to compare estimates of abundance and fry to smolt ratios between years. The estimated number of juveniles was highest in 1997, and a greater proportion of juveniles emigrated as fry during the sampling period that year. Estimated numbers were lowest over the sampling period in 1996. However, these differences may have been due to differences in monitoring periods.

Relationship of Juvenile Abundance to Environmental Factors

Effect of Streamflow on Juvenile Emigration

Flow data for the Mokelumne River were obtained from USGS gage 11323500, located below Camanche Dam. Figure B-13 shows the mean daily flow at the gage site during the egg incubation, juvenile rearing, and emigration period from 1994 to 1995 (October 1994 through June 1995) and the abundance of YOY chinook salmon emigrating from the Mokelumne River from late January through June 1995.

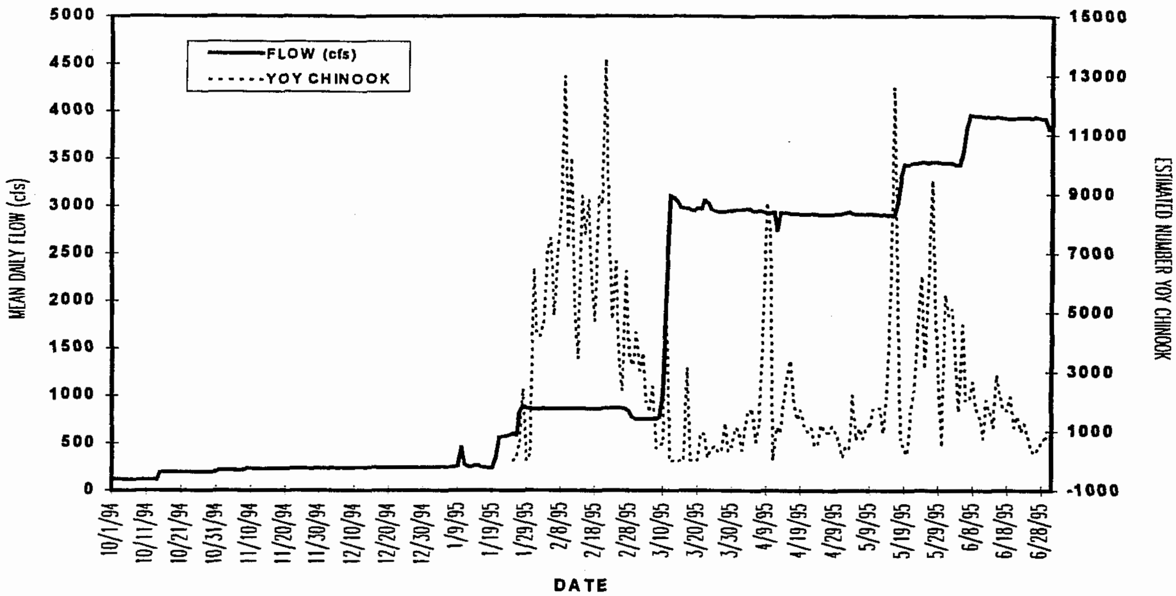

Figure B-13. Mean Daily Flow at Camanche Dam, October 1994 through June 1995, and Estimated Abundance of YOY Chinook Salmon Emigrating from the Mokelumne River, 1995

Flows from October 1994 through mid-January 1995 were relatively low and stable, ranging from 110 to 250 cfs. Flows increased in mid to late January to about 850 cfs and remained relatively stable through mid-March. Flows increased substantially in mid-March to about 3,000 cfs; flows increased again in mid-May and early June. The timing of emigration did not appear to be strongly related to changes in flow. Peak fry emigration occurred in February during a period of relatively stable flows. Peak emigration of larger juveniles also occurred during a period of relatively stable flows in early April and mid-May.

Figure B-14 shows the mean daily flow at the gage site during the egg incubation, juvenile rearing, and emigration period from 1995 to 1996 (October 1995 through June 1996) and the abundance of YOY chinook salmon emigrating from the Mokelumne River from January through June 1996.

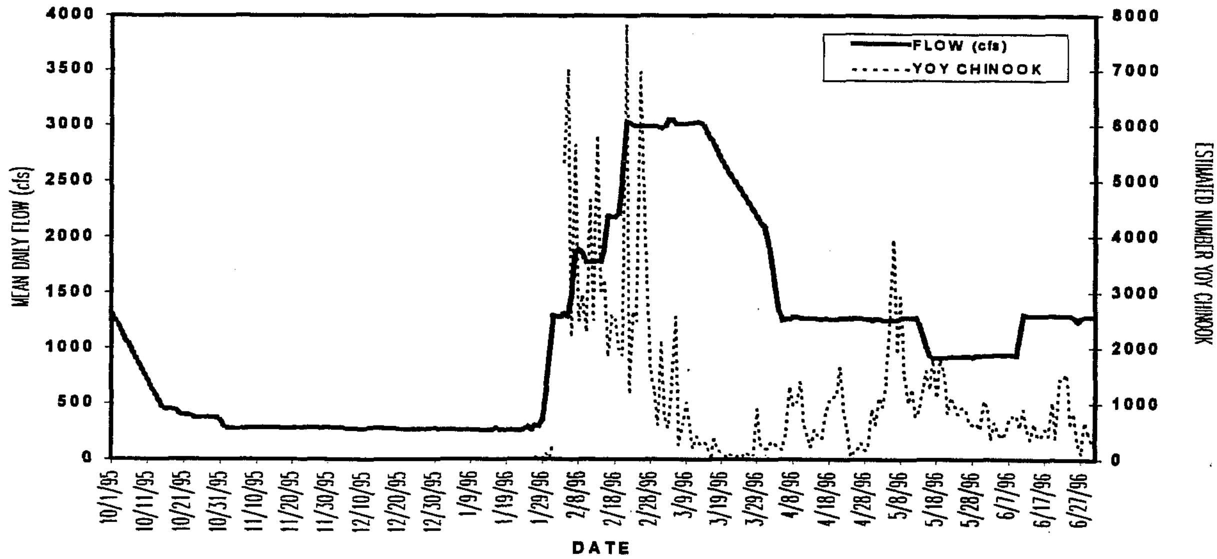

Figure B-14. Mean Daily Flow at Camanche Dam, October 1995 through June 1996, and Estimated Abundance of YOY Chinook Salmon Emigrating from the Mokelumne River, 1996

Flows in October declined from 1,320 cfs to about 300 cfs. Flows throughout November, December, and January were relatively low, remaining less than 300 cfs. Flows increased to a high of 3,000 cfs from late February through mid-March and then declined through the end of March to 2,000 cfs. Flows in April, May, and June were relatively steady, varying between 900 and about 1,200 cfs. The majority of fry emigrated during the high-flow period in February and early March, but it is unknown if flows had a significant effect on the timing of fry emigration. The peak in emigration of larger juveniles occurred in early May during a period of relatively constant flow.

Figure B-15 shows the mean daily flow at the gage site during the egg incubation, juvenile rearing, and emigration period from 1996 to 1997 (October 1996 through June 1997) and the abundance of YOY chinook salmon emigrating from the Mokelumne River from January through June 1997.

Flows were low and stable from October through the end of November. In December, flows increased steadily and reached highs of 5,000 cfs from early January through mid-February. Flows reached higher levels in 1997 than in 1995 or 1996, and high flows occurred much earlier in the rearing period. Flows declined through late February, March, and April. In May and June, flows were relatively low and stable. Peak fry emigration occurred in late February, similar to other years, during a period of high but declining flows. Emigration of larger juveniles was prolonged and did not appear to be related to changes in flow.

Flows in December 1996 and January and February 1997 in the lower Mokelumne River were probably not high enough to result in bed movement or scouring of eggs and fry in the gravel. It is unlikely that high flows in 1997 adversely affected the year class.

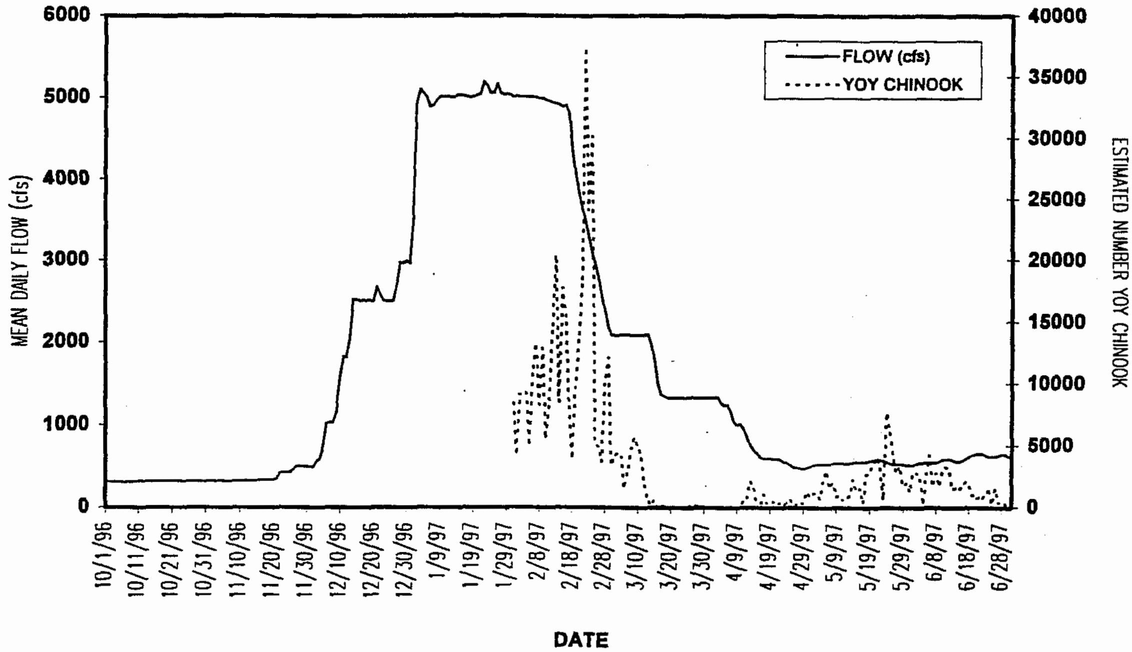

Figure B-15. Mean Daily Flow at Camanche Dam, October 1996 through June 1997, and Estimated Abundance of YOY Chinook Salmon Emigrating from the Mokelumne River, 1997

Effect of Water Temperature on Spawning and Egg Incubation

Mean daily water temperatures collected by EBMUD at Mackville Road within the spawning and rearing reach from October 1994 through June 1995 are shown in Figure B-16. Temperatures during October through mid-November, 1995, when chinook salmon spawning and egg incubation were occurring in the river, ranged from 56 to 60.8° F. These temperatures slightly exceeded the optimum temperature range reported in the literature for chinook salmon spawning and egg incubation of 41.0 - 56.0°F (Rich 1987; Reiser and Bjornn 1987) and were within the range reported as resulting in low chronic stress for these life stages (Leidy and Li 1987). From November 15 on, temperatures dropped below 56° F.

Mean daily water temperatures collected by EBMUD at Mackville Road from October 1995 through June 1996 are shown in Figure B-17. Temperatures during October and November 1995, when chinook salmon spawning and egg incubation were occurring in the river, ranged from 60 to 61.2° F. These temperatures slightly exceeded the optimum temperature range for chinook salmon spawning and egg incubation of 41.0 - 56.0° F (Rich 1987; Reiser and Bjornn 1987) and were within the range reported as resulting in low chronic stress for these life stages (Leidy and Li 1987). During December, temperatures dropped from about 60 to 55° F by the end of the month.

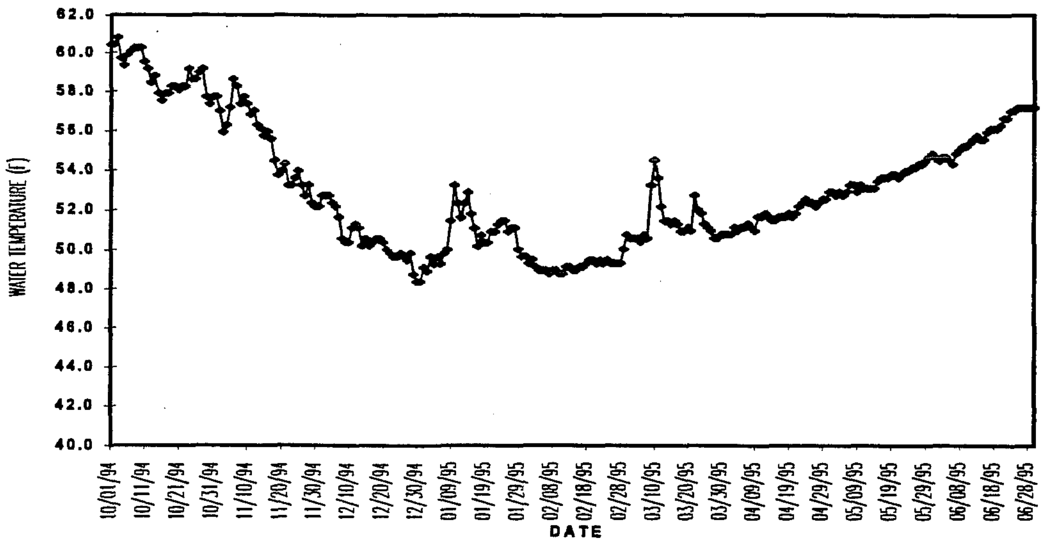

Figure B-16. Mean Daily Water Temperature at Mackville Road on the Lower Mokelumne River, October 1994 to June 1995

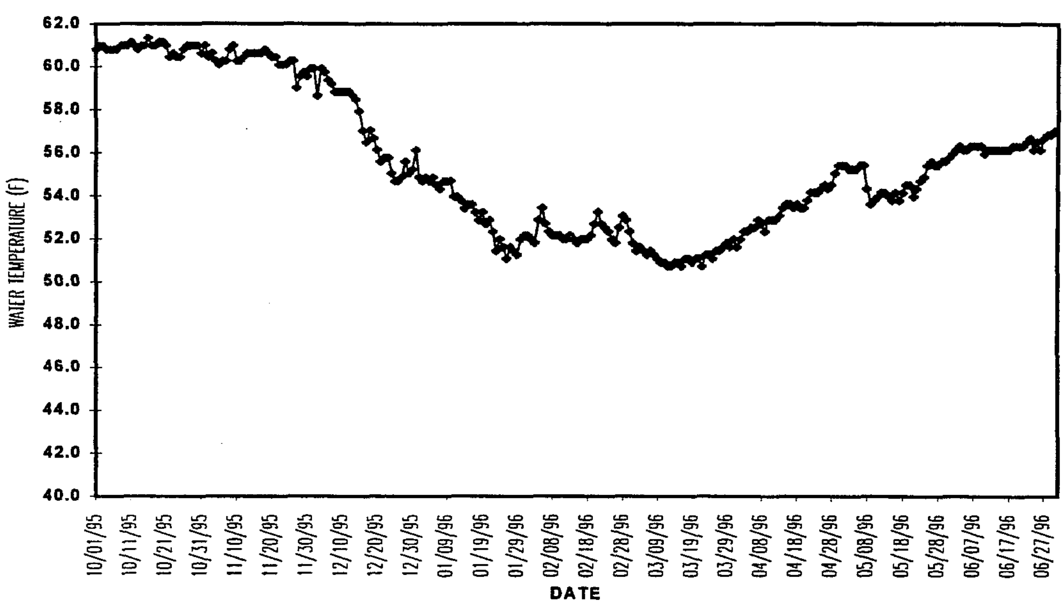

Figure B-17. Mean Daily Water Temperature at Mackville Road on the Lower Mokelumne River, October 1995 to June 1996

Mean daily water temperatures collected by EBMUD at Mackville Road from October 1996 through June 1997 are shown in Figure B-18. Temperatures during October and November 1996, when chinook salmon spawning and egg incubation were occurring in the river, ranged from 57 to 60.8° F. These temperatures slightly exceeded optimum temperatures for chinook salmon spawning and egg incubation of 41.0 - 56.0° F (Rich 1987; Reiser and Bjornn 1987) and were within the range reported as resulting in low chronic stress for these life stages (Leidy and Li 1987).

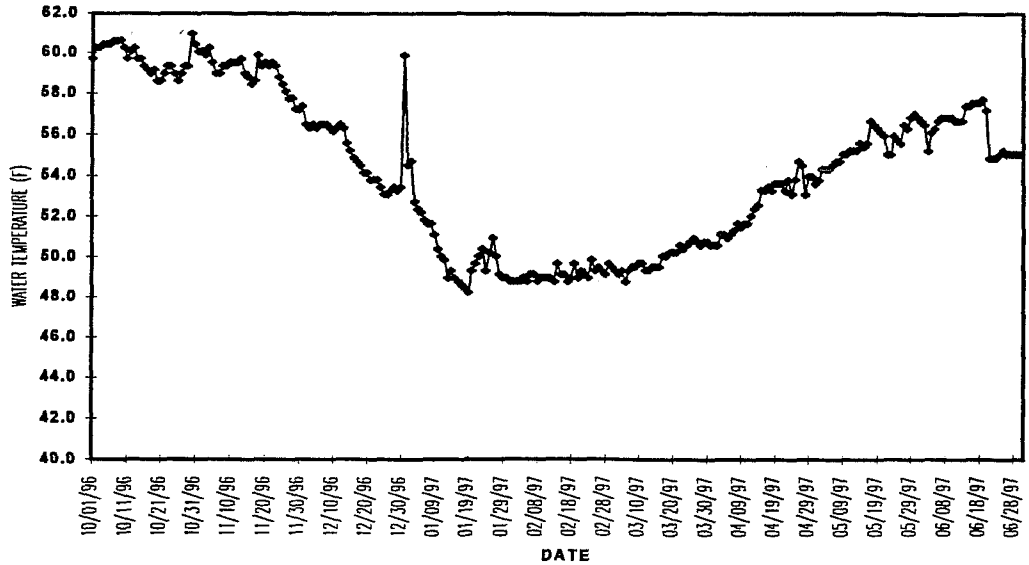

Figure B-18. Mean Daily Water Temperature at Mackville Road on the Lower Mokelumne River, October 1996 to June 1997

Stanislaus River

Methods

Rotary screw traps have been used since 1994 to monitor juvenile emigration on the lower Stanislaus River at Caswell State Park (RM 8.6)(Demko and Cramer 1997, 1998). In 1994, CDFG fished one trap, and in 1995 USFWS fished two traps at the site. In these years, traps were not fished throughout the entire fall-run emigration period; catches were relatively low and sampling missed significant portions of the emigration period.

In 1996 and 1997, sampling was conducted by S.P. Cramer and Associates under contract to the USFWS. Funding was provided by the AFRP CVPIA Restoration Account. In 1996, traps were fished from February 6 through June 30, covering most of the emigration period. In 1997, traps were installed after the start of emigration, on March 19, due to high flows in January and February. Data from 1996 and 1997 are included in this report, with recognition that data from 1997 do not represent a complete emigration season.

In general, methods used for rotary screw trap sampling on the lower Stanislaus River in 1996 and 1997 were consistent with the CAMP standard protocol.

In each year, two rotary screw traps (8-foot diameter) were fished side-by-side at Caswell State Park (RM 8.6). Traps were fished 24 hours per day, 7 days per week and checked once or twice daily. During peak emigration periods, or when debris loading was heavy, the trap was monitored every 2 to 3 hours. During each trap check, fish were removed from the trap, sorted, and counted by species. Up to 30 individuals of each species were measured (fork length to the nearest 0.5 mm). Measured salmonids were visually classified as fry, parr, or smolts. Turbidity (as NTUs), velocity at trap mouth, water temperature, and effort were recorded each day. Daily water temperatures were also calculated from continuously recording thermographs. Flow data used in this report were obtained from USGS gage 11302000 located at Goodwin Dam near Knight's Ferry, California.

Trap efficiency tests were conducted with a total of 15 release groups in 1996, between February 14 and June 10, and a total of 5 release groups in 1997. Tests were conducted with naturally produced fish when available in sufficient numbers; fish from the Merced River Fish Facility were also used. Trap efficiency tests were limited in 1997 by the availability of hatchery fish for use in tests. Fish were marked by cold brand or dye inoculation, using Alcian Green and Alcian Blue dyes. A specific pattern was used to indicate the week of marking. After marking, fish were held 1 to 4 days in a net pen and then released 1/4 mile upstream of the trap site. During each efficiency test, all fish measured were also checked for marks.

Calculated efficiency rates (number of recaptures/number of marked fish in release group) varied from 0.0021 to 0.121 in 1996 and from 0.016 to 0.036 in 1997. Following 1997 sampling, a regression was developed relating flow and water turbidity to trap efficiency. Predicted efficiency values from the regression equation were applied to raw catch data from both years on each date to estimate the number of juvenile chinook salmon emigrating by size class (estimated number = raw catch /predicted trap efficiency rate).

Results

Estimated Abundance

The estimated daily number of fry and other juvenile YOY chinook salmon emigrating from the lower Stanislaus River in 1996 and 1997 are shown in Figures B-19 and B-20.

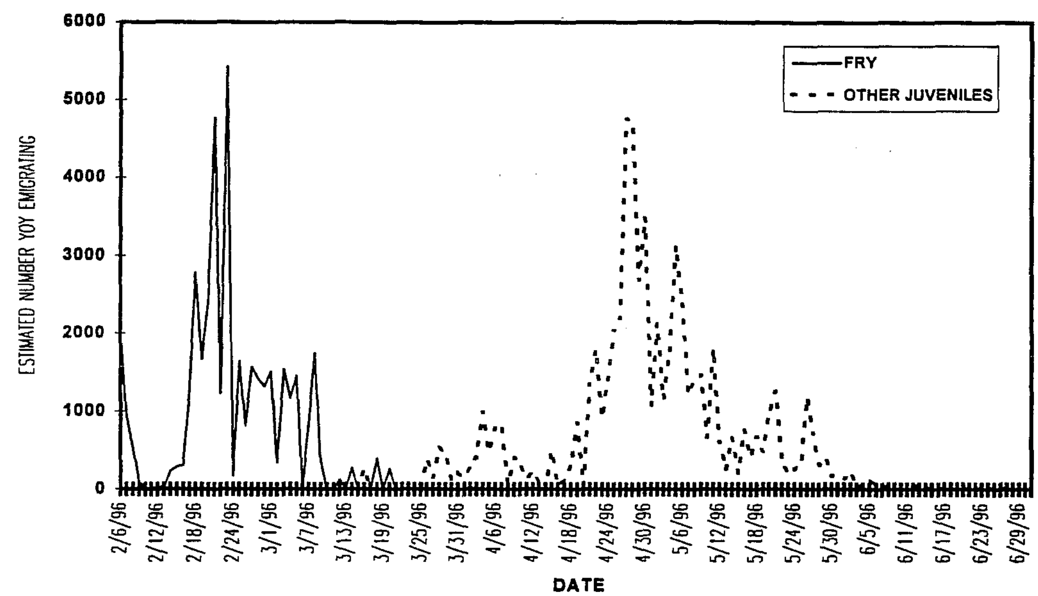

Figure B-19. Estimated Number of YOY Chinook Salmon (Fry and Other Juvenile YOY) Emigrating from the Lower Stanislaus River by Day, 1996

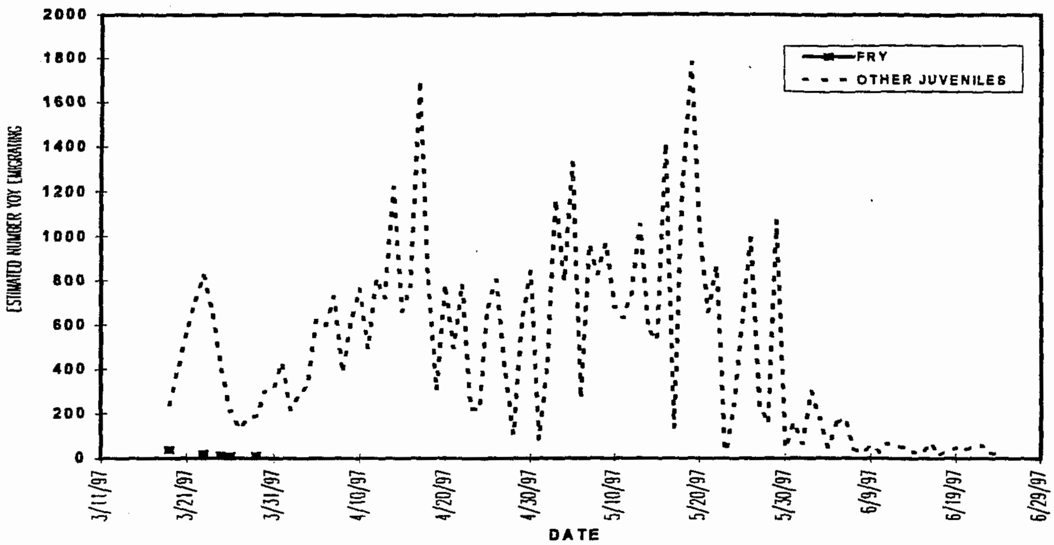

Figure B-20. Estimated Number of YOY Chinook Salmon (Fry and Other Juveniles) Emigrating from the Lower Stanislaus River by Day, 1997

In 1996, there were two distinct peaks of emigration. In mid to late February, the abundance of fry reached a peak; in late April, the abundance of smolt size fish reached a maximum. In 1997, few fry (only six) were caught due to the late start of sampling in mid-March. Significant numbers of fry probably emigrated prior to the start of sampling during high flows in January and February. No distinct peak in emigration occurred in 1997; juveniles emigrated from mid-March through the end of sampling in June, with slightly higher abundance in mid-April and mid-May.

Between February 6 and June 30, 1996, an estimated 105,207 YOY fall-run chinook salmon emigrated from the lower Stanislaus River. Of this total, an estimated 41,026 fish (39 percent) emigrated as fry less than or equal to 50 mm; an estimated 64,187 fish emigrated as larger juveniles (greater than 50 mm and less than 125 mm).

Between March 19 and June 27, 1997, an estimated 46,920 YOY fall-run chinook salmon emigrated from the lower Stanislaus River. Of this total, only an estimated 85 fish emigrated as fry less than or equal to 50 mm.

The total estimated number of juveniles emigrating was higher in 1996 than in 1997; however, a large number of fry probably emigrated prior to the start of sampling in 1997.

Relationship of Juvenile Abundance to Environmental Factors

Effect of Streamflow on Juvenile Emigration

Flow data for the lower Stanislaus River were obtained from USGS gage 11302000 located at Goodwin Dam near Knight's Ferry, California. Figure B-21 shows the mean daily flow at the gage site during the egg incubation, juvenile rearing, and emigration period from 1995 to 1996 (October 1995 through June 1996) and the abundance of YOY chinook salmon emigrating from the lower Stanislaus River. Figure B-22 shows the mean daily flow at the gage site from October 1996 through June 1997 and the abundance of YOY chinook salmon emigrating from the river.

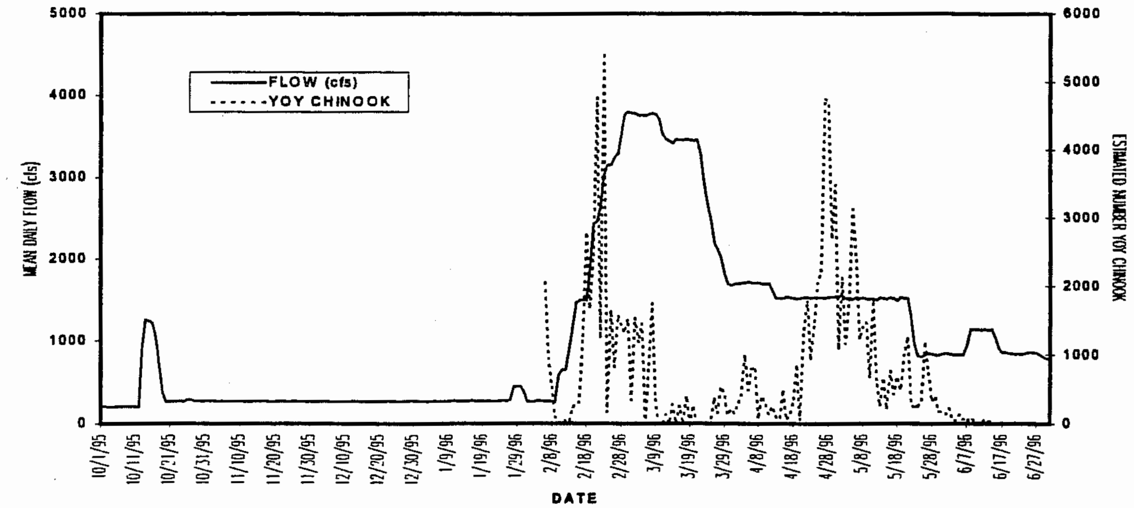

Figure B-21. Mean Daily Flow at Goodwin Dam, October 1995 through June 1996, and Estimated Abundance of YOY Chinook Salmon Emigrating from the Stanislaus River, 1996

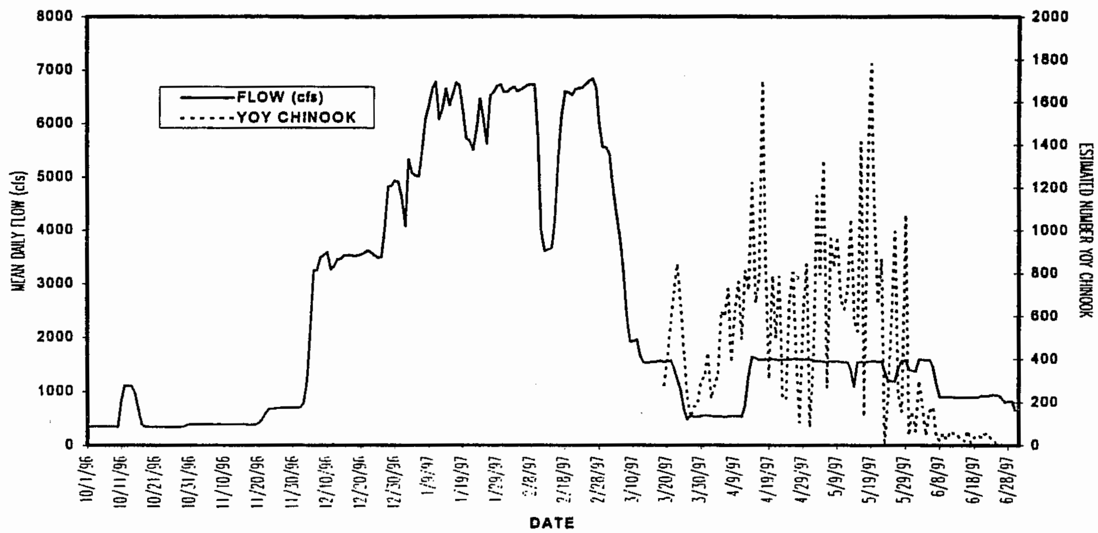

Figure B-22. Mean Daily Flow at Goodwin Dam, October 1996 through June 1997, and Estimated Abundance of YOY Chinook Salmon Emigrating from the Stanislaus River, 1997

In either year, the timing of emigration did not appear to be strongly influenced by streamflow. In 1996, the timing of peak smolt emigration occurred during an extended period of nearly constant flow. Smolt passage peaked between April 19 and May 11, but flow remained nearly constant at 1,700 to 1,800 cfs from March 29 through May 21. In 1997, the pattern of emigration showed only a weak relationship to changes in streamflow. The sharp drop in late March coincided with an increase in passage, the sharp increase in flow during mid-April was followed by only two days with increased passage, and the drop and increase in flow during mid-May was followed by a few days of elevated passage rates. The number of chinook emigrating decreased in late May, and few chinook emigrated in June of 1997.

In 1997, it is likely that significant numbers of fry emigrated prior to the start of sampling. High flows (up to 7,000 cfs) occurred in the lower Stanislaus River through January and February. These flows were probably not high enough to result in significant gravel bed movement or scouring of eggs and fry (Steve Baumgartner, CDFG, personal communication). Overall, high flows may have benefited juveniles emigrating in 1997.

Effect of Water Temperature on Spawning and Egg Incubation

Mean daily water temperatures obtained from USGS gage 11302000 located at Goodwin Dam near Knight's Ferry, California, from October 1995 through June 1996 and from October 1996 through June 1997 are shown in Figures B-23 and B-24, respectively. Temperatures measured at this station throughout the fall-run chinook salmon spawning, egg incubation, rearing, and emigration periods were within optimum levels in both years (less than 54° F). However, temperatures through the spawning and rearing reach were probably somewhat higher than temperatures measured at the gage site.

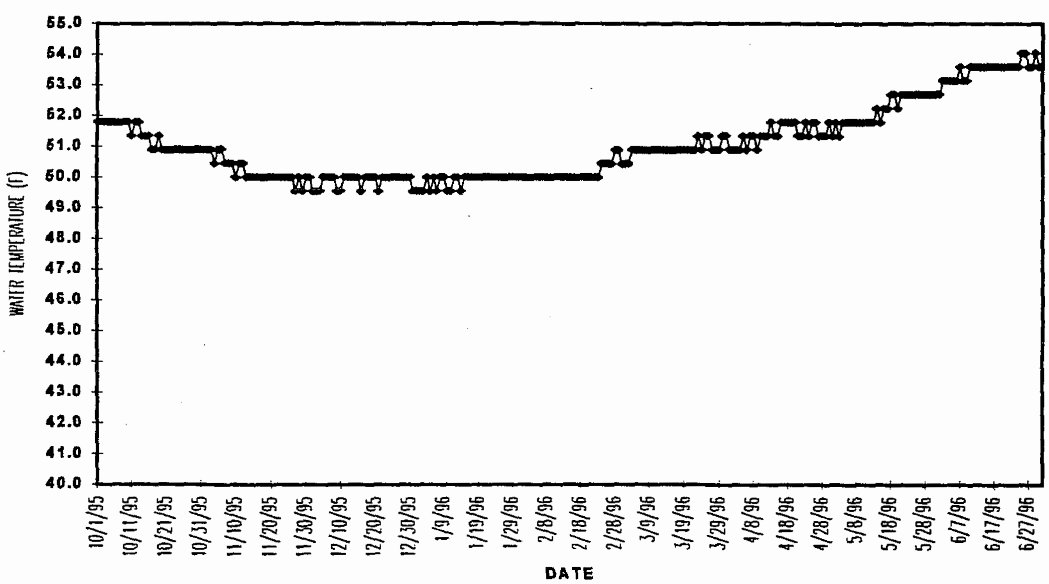

Figure B-23. Mean Daily Water Temperature at Goodwin Dam on the Lower Stanislaus River, October 1995 through June 1996

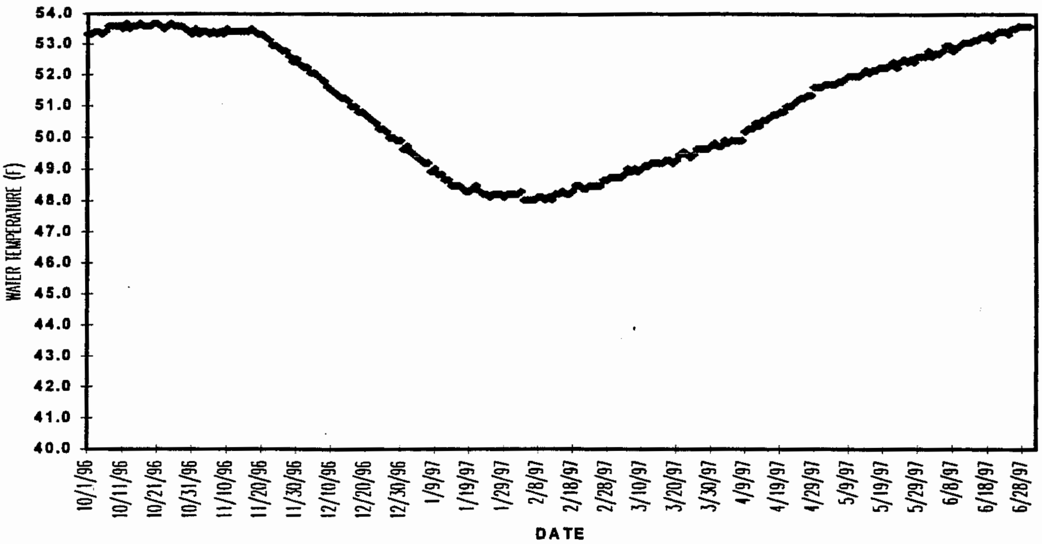

Figure B-24. Mean Daily Water Temperature at Goodwin Dam on the Lower Stanislaus River, October 1996 through June 1997

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